CORIS360®
Gamma Imaging System
User Guide

PRODUCT BY

Australian Government | ANSTO

Version 1.3

CE

ANSTO
New Illawarra Road,
Lucas Heights NSW 2234 Australia

LEGAL DISCLAIMER

By using ANSTO's CORIS360® radiation imaging system (Product) and ANSTO's proprietary CORIS360® Radiation Imaging Software (Software), you agree to be bound by the content of this disclaimer, the Terms and Conditions – Sale of CORIS360®, as well as any terms accepted when you first accessed the Software.

Your use of the CORIS360® is at your own risk. You must evaluate, and bear all risks associated with, the use of any tangible or intangible material produced or output generated through your use of the CORIS360® including reliance on the accuracy, completeness, suitability for any purpose or usefulness of any such material produced or output generated through your use of the CORIS360®.

DISCLAIMER OF WARRANTY

Except as provided for in the Terms and Conditions – Sale of CORIS360®, ANSTO does not guarantee or warrant that any tangible or intangible material produced or output generated through your use of the CORIS360® will be suitable or fit for any particular purpose of the uses to which you may put any such material produced or output generated through your use of the CORIS360® and to the maximum extent permitted by law ANSTO accepts no liability for the manner in which the CORIS360® may operate, or results that can be received from the CORIS360®.

To the maximum extent permitted by applicable law:

a) the Software is provided "as is" and "as available", with all faults and without warranty of any kind.
b) all conditions, warranties, undertakings or representations, express or implied, arising by statute general law or otherwise are expressly disclaimed and excluded.
c) ANSTO disclaims and excludes all statutory and implied warranties, including without limitation, warranties of merchantability, accuracy, non-infringement of third party rights, and fitness for a particular purpose and warranties against hidden or latent defects.
d) ANSTO has no liability to you and is released by you from any and all liability:
    i. whether in contract, tort (including negligence and breach of statutory duty) in relation to the Software;
    ii. including but not limited to liability for:
        A. personal injury or death;
        B. damage to property;
        C. any lost revenue, lost opportunity, increased costs or expenses, lost profits or lost business;
        D. loss of data;
        E. any special loss or damage;
        F. any indirect, incidental or consequential loss or damage of any nature.

INTELLECTUAL PROPERTY NOTICES

CORIS360® is a registered trademark of the Australian Nuclear Science and Technology Organisation.

Removal, concealment, or alteration of any trade marks, business names or indicia, proprietary notices (including trade mark and copyright notices) that may be affixed to or contained within the Software, Product or this User Guide is prohibited.

ANSTO retains all rights, title and interest in the intellectual property in the Software and the Product (as defined in the Terms and Conditions – Sale of CORIS360®) and this User Guide. Except where specified, ANSTO does not transfer ownership or licence any intellectual property subsisting in the Product, the Software or this User Guide.

You must not seek, claim or take any steps to invalidate or prejudice ANSTO's Intellectual Property rights in the Product, the Software or this User Guide.

Unless otherwise permitted in the Terms and Conditions – Sale of CORIS360®, it is prohibited to:

a) copy, adapt, translate, manufacture or otherwise exercise any intellectual property rights in any of ANSTO's patents, trade marks, service marks, logos, industrial designs or copyright materials; and
b) to rent, lease, lend, sell, redistribute, or sublicense the Software, the Product or this User Guide without the express written consent of ANSTO.

To the extent that any open source code may be made available at the same time as the Software, such open source code is provided as a courtesy only and is subject to the terms of the relevant open source licence(s) which govern the use of open source software.

General Safety Information

Do not install substitute parts or perform any unauthorised modification to this device. Contact the CORIS360® customer support team for any servicing or repairs to ensure the safety features are maintained. If required, contact the customer support team at *support@coris360.com.*

Use the device only as specified. Review the following safety precautions to avoid injury and prevent damage to this device. Carefully read all instructions and retain these instructions for future reference.

Comply with local and national safety codes.

For correct and safe operation of the device, it is essential that the user follows generally accepted safety procedures in addition to the safety precautions specified in this manual.

Only qualified personnel from the CORIS360® customer support team should repair, service or perform maintenance on the device.

This device is classified as Group 1 Class B ISM (Industrial, Scientific and Medical) equipment. This means the device does not intentionally generate radio-frequency energy and the device is suitable for use in domestic and residential areas, and can be connected to public mains power.

Injury Precautions

Do Not Insert Power Supply into Device while Powered	To avoid electric shock, sparking or a fire hazard, do not insert the power supply into this device while the power supply is powered.
Do Not Remove Covers	To avoid electric shock or fire hazard, do not operate this device with covers or panels removed.
Do Not Operate in Wet Conditions	To avoid electric shock and ensure proper functioning of this device, do not operate this device in wet conditions (in accordance with IP54 rating).
Use Care When Lifting the Device	Use care and follow proper lifting technique when lifting and carrying the device. The device is provided with a handle at the top of the device and hand slots at the bottom.

Product Damage Precautions

Use Proper Power Supply	Use only the power supply provided with this device. Do not operate this device from any other power supply.
Do Not Plug or Unplug Detector while Device is Switched On	To avoid damage to the detector, do not plug or unplug the detector from the device while the device is powered on.
Do Not Operate if Suspected Failures	If there is suspected damage to the device, do not operate or power the device and have it inspected by qualified CORIS360® personnel.
Do Not Operate Outside of Operating Temperature	To avoid damage to the device and ensure optimal performance, do not operate the device outside of the 5°C – 40°C (41°F – 104°F) temperature range.
Use Care When Handling the Device	Use care when handling and moving the device. Dropping or rapidly shaking the device can result in damage to the device.

Safety Terms and Symbols

WARNING		The WARNING sign indicates a potential hazard. It calls attention to a procedure, practice or condition which, if not followed, could possibly cause bodily injury or death. If a WARNING is indicated, do not proceed until its conditions are fully understood and met.
CAUTION		The CAUTION sign indicates a potential hazard. It calls attention to a procedure, practice or condition which, if not followed, could possibly cause damage to equipment. If a CAUTION is indicated, do not proceed until its conditions are fully understood and met.

Contents

1. BACKGROUND

CORIS360® is a gamma-ray imaging system which has been developed and built at ANSTO. The technology behind CORIS360® is based on the theory of compressed sensing, which enables gamma-ray images to be acquired in a fraction of the samples typically required by conventional imaging techniques.

CORIS360® can identify and locate the presence of gamma emitting radionuclides by creating a 360° horizontal × 90° vertical gamma image, overlaid onto a panoramic optical image covering the same field of view. CORIS360® uses a spectroscopic detector which allows for the identification of gamma emitting radionuclides in the 40 keV to >3 MeV range. These detectors are also able to detect the presence of neutrons.

CORIS360® has a novel dual cylindrical mask configuration that surrounds a single central detector. The gamma image acquisition occurs by collecting gamma spectra over a series of individual samples. The dual masks shield the incident gamma radiation, with the rotation of the masks creating a series of unique mask patterns. A gamma spectrum is recorded at each mask position, building up a series of encoded gamma spectrum samples which can then be reconstructed into a gamma image.

2. EQUIPMENT SET UP

2.1. Equipment List

CORIS360® comes with the following items. For any issues regarding equipment, please contact the customer support team at *support@coris360.com*. A digital copy of this user guide can also be accessed through the **CORIS360® Radiation Imaging** software by clicking ***Help > Manual*** from the menu bar at the top of the window.

	CORIS360® Imager
	CORIS360® Imaging and processing software
	Tripod
	Ruggedised carry case
	Two detectors
	Power and data cables
	^{152}Eu calibration puck
	Hex Key

2.2. Operating Requirements

The operating requirements for CORIS360® and the connected computer are as follows:

Power Supply	100 VAC – 240 VAC (47 Hz – 63 Hz) Input Provides 24 VDC and minimum 90 W to CORIS360®	
Operating Temperature	5 °C – 40 °C (Ambient) | 41 °F – 104 °F (Ambient)	
Dose Rate Range	0.5 µSv/h – 2 mSv/h (CLLBC15 detector) 1 µSv/h – 40 mSv/h (CLLBC05 detector) Both for ^{137}Cs source	
Minimum Computer Specifications	**Processor:**	Intel Core i5 6th Generation (or equivalent)
	Memory:	4 GB RAM
	Hard Drive:	Solid State with 1 GB available
	Operating System:	Windows 7 or later (64 Bit)
	Display:	14” screen, 1920 x 1080 resolution
	Network Interface:	Ethernet or Wi-Fi
Humidity Range	Max 70% relative humidity, non-condensing	
Altitude Range	Max 3000 m	

2.3. Removing CORIS360® from the Transportation Case

WARNING. *Incorrect lifting technique when handling the system can result in injury. To avoid this, ensure proper lifting technique is used at all times when lifting and carrying the system.*

CAUTION. *Dropping or rapidly shaking the system can damage the system. To avoid this, ensure care is always used when handling or moving the system.*

To remove CORIS360® from the transportation case, it is recommended that proper lifting technique is always used. CORIS360® has a weight of 15 kg (33 lbs). When lifting the device out of the case, always use two hands, placing one hand at the top and bottom of the system. Do not attempt to lift or rotate the system using the removable circular lid at the top of the device.

NOTE. Whenever CORIS360® is being transported, ensure that any detector inside the device has been removed and placed in its corresponding location in the transportation case.

2.4. Position CORIS360® on the Tripod

Set up the supplied tripod by undoing the clips at the base of the tripod and extending the legs out to the desired height. Ensure that the tripod is level, that the legs are locked in place once extended and that the tripod feet are flat on the ground prior to placing CORIS360® on the tripod.

> ***WARNING.*** *Incorrect lifting technique when handling the system can result in injury. To avoid this, ensure proper lifting technique is used at all times when lifting and carrying the system.*

> ***CAUTION.*** *Dropping or rapidly shaking the system can damage the system. To avoid this, ensure care is always used when handling or moving the system.*

CORIS360® is attached to the tripod via the provided tripod mount. Ensure the mount is in the unlocked position prior to placing the system on top. Lock the system to the tripod by closing the mount latch.

NOTE. If the tripod needs to be moved while attached to CORIS360®, always detach the device and tripod and move separately. Moving the two items while attached can be unstable.

The ideal placement for CORIS360® is on a tripod 1 m – 1.5 m off the ground, with nothing obstructing the 360° horizontal × 90° vertical view surrounding the device. **It is best practice that there are no objects within a 1 m radius of the device**. If necessary, due to operational constraints, CORIS360® may be placed close to objects (such as a wall, or in an enclosed space). However, this may lead to unrealistic image artefacts in the optical image. Importantly, it should be noted that device placement will never affect the gamma component of the image.

NOTE. The device placement, and its proximity to other objects, will never affect the gamma component of the image. Only the stitching of the optical image will be affected.

2.5. CORIS360® Connections

WARNING. *Inserting the power supply into the device while powered can result in electric shock, sparking or a fire hazard. To avoid this, ensure the power supply is never powered when plugging into the system.*

CAUTION. *Operating the system using a power supply that does not input the correct voltage can damage the system. To avoid this, ensure only the power supply provided is used when operating the system.*

Connect CORIS360® to mains power using the power cable provided. The mains power should have an input of 100 VAC – 240 VAC (47 Hz – 63 Hz) and must be capable of providing 24 VDC and a minimum of 90 W to CORIS360®. Tighten the collar on the power cable plug to secure in place. If running off a battery, CORIS360® still requires the same input provided by the supplied power pack (24 VDC and a minimum of 90 W).

Connect CORIS360® to the computer either through the Ethernet cable or Wi-Fi dongle provided (Wi-Fi only available for firmware version 1.0.6 and above).

To communicate with CORIS360® using the Ethernet cable, plug the cable into the Ethernet port on CORIS360® and the computer. If the computer being used does not have an Ethernet port, a USB to Ethernet adapter will be required. Once plugged in, CORIS360® will automatically connect to the computer, indicated by the ***CORIS360 Status*** in the bottom right corner of the software window reading ***"Connected"***.

NOTE. For CORIS360® devices with firmware versions below 1.0.6, a static IP address will need to be setup to connect to CORIS360® instead of connecting automatically. This will need to be set up any time the user connects CORIS360® to a new computer. See Appendix A for steps on how to complete this setup.

NOTE. Once an image capture has begun, the Ethernet cable can be unplugged, or the Wi-Fi disconnected, from CORIS360® and the image capture will continue to run as normal. To stop the image capture or communicate with the device for any reason, the Ethernet cable must be plugged back in, or the Wi-Fi reconnected.

To communicate with CORIS360® using Wi-Fi, plug the Wi-Fi dongle into the USB port on CORIS360®. Connect to the Wi-Fi from the computer using the Network icon in the Windows taskbar. The name of the network for your CORIS360® device is "CORIS360_<SERIAL NUMBER>". For example, a device with serial number "001C10" will have a network name "CORIS360_001C10". The serial number of your device can be found on the bottom of your CORIS360®. The default Wi-Fi password for your CORIS360® device is "coris360".

The software also provides the user with the ability to change the Wi-Fi password and to disable the Wi-Fi altogether (meaning no Wi-Fi signal will be emitted). To make these changes, open the **CORIS360® Detector Calibrator** tool and click ***Tools > Device Settings*** from the menu bar at the top of the window. See Section 6.1 for further description on the ***Device Settings*** window.

Lastly, after all connections have been made, push the power button to turn the system on. The button will light up green, indicating the system is powered. To turn the system off, hold down the power button for 3 seconds.

A labelled photo of the CORIS360® connections is shown below:

1. Power Button
2. Ethernet Port
3. USB Port
4. Power Cable Port

2.6. Changing the Detector

Two detectors are supplied with CORIS360®, the details of which are given in the table below.

Detector	Colour	Max Angular Resolution	Dose Rate Range
CLLBC15 Cylindrical 1.5” CLLBC Scintillator with SiPM Array	Red	20° ± 1°	0.5 µSv/h – 2 mSv/h (0.05 mrem/h – 200 mrem/h)
CLLBC05 Cylindrical 0.5” CLLBC Scintillator with SiPM Array	Blue	15° ± 1°	1 µSv/h – 40 mSv/h (0.1 mrem/h – 4000 mrem/h)

Each detector is encased in a cylindrical shell coloured according to detector size, as shown in the images below. The 1.5" CLLBC detector (CLLBC15) is red and the 0.5" CLLBC detector (CLLBC05) is blue. The detectors are equipped with in-built temperature compensation to ensure optimal performance throughout the entire operating temperature range (5 °C – 40 °C | 41 °F – 104 °F). The red detector has a greater detection efficiency due to its larger volume and will result in significantly faster detection and imaging times. **The CLLBC15 (red) detector should be used in most scenarios**. The blue detector has a lower detection efficiency due to its smaller volume, however it has a better maximum angular resolution and larger dose rate range. This detector should be used in scenarios where higher angular resolution is required or in very high dose rate scenarios (> 2 mSv/h).

To insert/remove a detector from the system:

CAUTION. *Inserting/removing the detector from the system while it is switched on can damage the detector. To avoid this, ensure the system is always switched off before inserting/removing the detector.*

1. First, ensure the system is switched off before inserting or removing the detector.
2. Using the supplied M5 hex key, unscrew and remove the circular lid on top of the CORIS360® system.
3. If a detector is already in the system, gently pull the detector directly upwards to remove it.
4. Insert the new detector into the system, using the triangular arrow on top of the detector casing (shown in the image above) as a guide by pointing the arrow towards the front of the system.
5. When the detector and system are correctly aligned (a slight dip will be felt), push the detector gently, but firmly, into the connector.
6. Check that the detector is properly attached by ensuring it cannot be easily lifted.
7. Re-attach and screw in the circular lid for CORIS360®.

2.7. Software Installation and Updates

Before the user can operate CORIS360®, they must first install the **CORIS360® Radiation Imaging** software. To install the software:

1. Using a computer with the specifications detailed in Section 2.2, download the software from the downloads page of the CORIS360® website (*www.coris360.com*).
2. Run the downloaded installer and follow the prompts to complete the installation. A desktop shortcut will be created during the installation process.
3. The **CORIS360® Radiation Imaging** software is now ready to run.

To uninstall the **CORIS360® Radiation Imaging** software:

1. Navigate to the directory where the software was installed
   a. The default folder name is "CORIS360" and the default location is "C:\Program Files".
   b. The user can also navigate to the folder by right-clicking the **CORIS360® Radiation Imaging** software shortcut on the computer desktop and selecting "Open file location".
2. Once in the folder, double click "maintenancetool.exe" and follow the prompts to complete the uninstallation.

The **CORIS360® Radiation Imaging** software automatically checks for software updates when there is an internet connection. This automatic check can be turned off in the ***Settings*** window if desired. The user can also manually check for updates whenever they like by clicking ***Help > Check For Updates*** from the menu bar at the top of the software window. When notified that there is a new software version available, it is recommended that the user follows the prompts and updates their software to the latest version. To update the software:

1. Follow the prompts to download the latest software version (*.exe file).
2. Run the downloaded installer and follow the prompts to complete the installation.
3. If desired, uninstall the old **CORIS360® Radiation Imaging** software using the instructions at the beginning of Section 2.7.

The firmware on CORIS360®, that is, the software on the CORIS360® device itself, will also periodically have updates available. When notified that there is a new software version available, it is again recommended that the user updates their software to the latest version. To update the firmware:

1. Follow the prompts to download the latest firmware version (*.iso file).
2. Open the **CORIS360® Detector Calibrator** tool and click ***File > Update CORIS360 Firmware…*** from the menu bar at the top of the window.
3. Open the downloaded *.iso file and follow the prompts to complete the firmware update.

3. QUICK START GUIDE

3.1. Set Up and Use CORIS360®

The following steps help the user quickly power on, connect and use the CORIS360® system.

WARNING. *Operating the system in wet conditions can result in electric shock. To avoid this, ensure the system is only operated in dry conditions in accordance with IP54 rating.*

CAUTION. *Operating the system outside of the operating temperature range can damage the system and decrease performance. To avoid this, ensure the system is only operated inside the operating temperature range.*

1. If not done previously, install the **CORIS360® Radiation Imaging** software using the steps in Section 2.7.
2. Connect CORIS360® to mains power and to the computer using the provided cables and Wi-Fi dongle.
3. If not done previously, insert the CLLBC15 (red) detector into the system using the steps in Section 2.6.
4. Turn the system on by pushing the power button. The button will light up green.
5. Open the installed **CORIS360® Radiation Imaging** software using the shortcut on the computer desktop.
6. Press the ***New Image*** button.
7. In the ***New Image Capture*** window, select a ***Sample Time*** (5 s recommended) and enter an ***Image Capture Name*** for the current image, then press ***Start*** ▶.
8. CORIS360® will begin the image capture and start taking samples.
9. Only the optical image will be displayed initially, with the centre of the panorama representing the front of CORIS360®.
10. If a peak is identified through the software's automatic radionuclide identification, the gamma image for that peak will be overlaid onto the optical image.
11. If no peak is automatically identified, a region of interest (ROI) must be added to produce the overlaid gamma image. To add an ROI:
    a. Click the ***+ Add ROI*** button in the bottom right of the software window.
    b. Enter a name for the ROI.
    c. Set the energy range of the ROI either by selecting a peak from the pre-defined dropdown library or by entering the ROI values manually. The ROI can also be edited by moving the ROI in the spectrum tab on the left.
    d. Click ***Add ROI*** and the reconstructed gamma image for the newly added ROI will be overlaid onto the optical image once it achieves an image quality above ***"Insufficient Data"***.
12. To complete the image capture, press the ***Stop*** ■ button. The data will be saved automatically in the user's home directory.

3.2. CORIS360® Imaging Tips

The following list provides tips on how to use the CORIS360® system, along with recommended settings and equipment to use. This list has been collated from the tips and recommendations located throughout this manual.

1. When setting up a new image capture, it is best practice that there are no objects within a 1 m radius of the device.
2. The CLLBC15 (red) detector is the recommended detector in most scenarios. This is due to the CLLBC15 detector having a greater detection efficiency, resulting in significantly faster detection and imaging times. The CLLBC05 (blue) detector should be used in higher dose rate (> 2 mSv/h) environments.
3. When selecting a sample time for a new image capture:
4. A sample time of 5 s is a suitable value for most gamma imaging scenarios where the dose rate at the detector is ≥ 1 µSv/h. Use the help button in the ***New Image Capture*** window for guidance.
    a. Ensure that for every region of interest (ROI) the user wants to analyse, the sample time is long enough such that the average number of ROI counts per sample is at least 100 counts. To check this value, click the ***Signal*** tab on the software's main window.
5. Increasing the sample time and acquiring more samples will both result in a more accurate gamma image. However, it is generally more beneficial to increase the sample time rather than acquire more samples.
6. When determining the required number of samples for an image capture, more complex scenarios (i.e. the more hot spots present) will require more samples.
7. When adding ROI's:
    a. The software contains an automatic radionuclide identification feature. This feature automatically identifies peaks in the spectrum and adds them to the ROI table.
    b. If custom ROI's are added following the radionuclide identification, a practical first choice is to add ROI's around any visible peaks in the spectrum that were not automatically identified.
    c. Double-clicking the centre of any visible peaks (after clicking ***+ Add ROI***) is the recommended method for adding a custom ROI as the software will automatically set an accurate width for the ROI.
    d. When adding a custom ROI, the software may display a warning message at the bottom of the ***Regions of Interest*** tab. This message informs the user that their ROI selection is not good. If these warning messages are ignored and the ROI is still selected, the resulting gamma image will likely be inaccurate and unstable.
8. When determining if a reconstructed image is accurate and whether the image capture can be stopped:
    a. The ***Image Quality*** column in the ROI table is the primary indicator of the accuracy and reliability of the gamma image.
    b. When determining if the user should stop an image capture, it is recommended that more samples be acquired until the gamma image for the ROI achieves an image quality of at least ***"Good"***.
9. When checking and re-calibrating the detector using the **CORIS360® Detector Calibrator**:
    a. It is recommended that the calibration of the detectors is checked at least monthly.
    b. Re-calibrating using the spectrum is the recommended method. This involves clicking on the centre of any visible peaks in the spectrum and assigning them an energy from the list of added sources.
    c. At least four peaks need to be assigned an energy to obtain an accurate calibration fit.
    d. Determining which peak is associated with which energy can be difficult when the calibration is wrong. A useful tool when assigning these peaks is to look at a spectrum of the source the user is calibrating with, labelled with the energies of its peaks. These gamma spectra are readily available online. A labelled ^{152}Eu source is provided in Appendix D.

3.3. CORIS360® Example Files

Three example files are provided with the **CORIS360® Radiation Imaging** software to assist the user with becoming familiar with the software and its features, and to demonstrate just some of the capabilities of CORIS360®. To access the example files, click ***File > Open Example*** from the menu bar in the top left of the software window.

The first example is the **Nuclear Security Example**, which demonstrates the usefulness of CORIS360®'s wide optical and gamma field of view, allowing multiple cars to be searched at one time. The software automatically identifies the ^{137}Cs in the spectrum, and then displays the resulting gamma image over the optical image. As the results show, multiple sources from the same radionuclide can be viewed on the same image overlay.

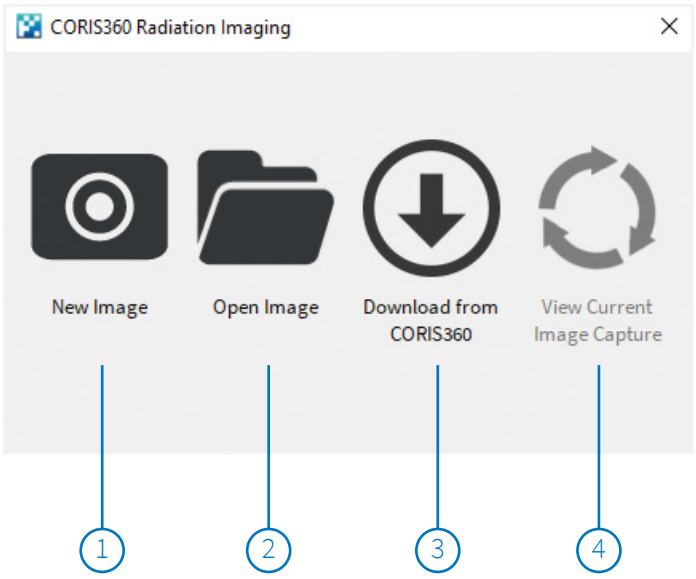
The second example is the **Multiple Sources Example**, which illustrates how CORIS360® can identify and image multiple sources in the one acquisition. By simply clicking through the automatically identified ROI's in the ***Regions of Interest*** table, the user is able to see what region of the spectrum is currently being reconstructed over, and the corresponding gamma image in the radiation overlay above. This example also illustrates CORIS360®'s ability to identify and image radionuclides over a wide energy range (from 40 keV to >3 MeV), all from a single acquisition.

The third example is the **X-Ray Example**, which shows CORIS360®'s ability to image at the very low energy range (< 40 keV) and the ability to image non-peak regions of a spectrum. As there are no peaks in this example's spectrum, no radionuclides will be automatically identified. Therefore, to view the gamma image, a custom ROI will need to be added by clicking ***+ Add ROI*** from the ***Regions of Interest*** tab at the bottom right of the software's main screen (see Section 4.3 for detailed instructions on adding a custom ROI). If the user wants to add a ROI below 40 keV, they must first click the ***Settings*** ⚙ button and check the box to allow ROI's below 40 keV. Note that the user should only check this box when performing an image capture if they are confident that they know what they are doing. Once the user adds a custom ROI, the gamma image will be displayed over the optical image.

4. USING THE CORIS360® RADIATION IMAGING SOFTWARE

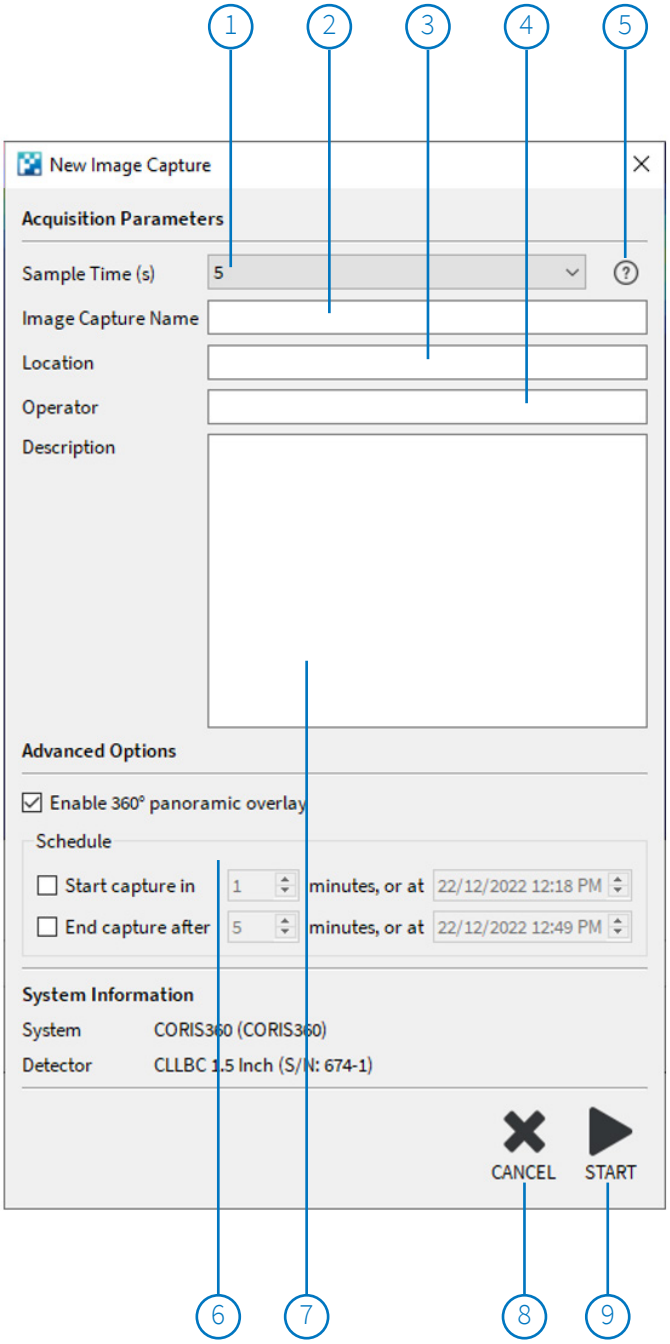
4.1. Software Features Explained

Home Window



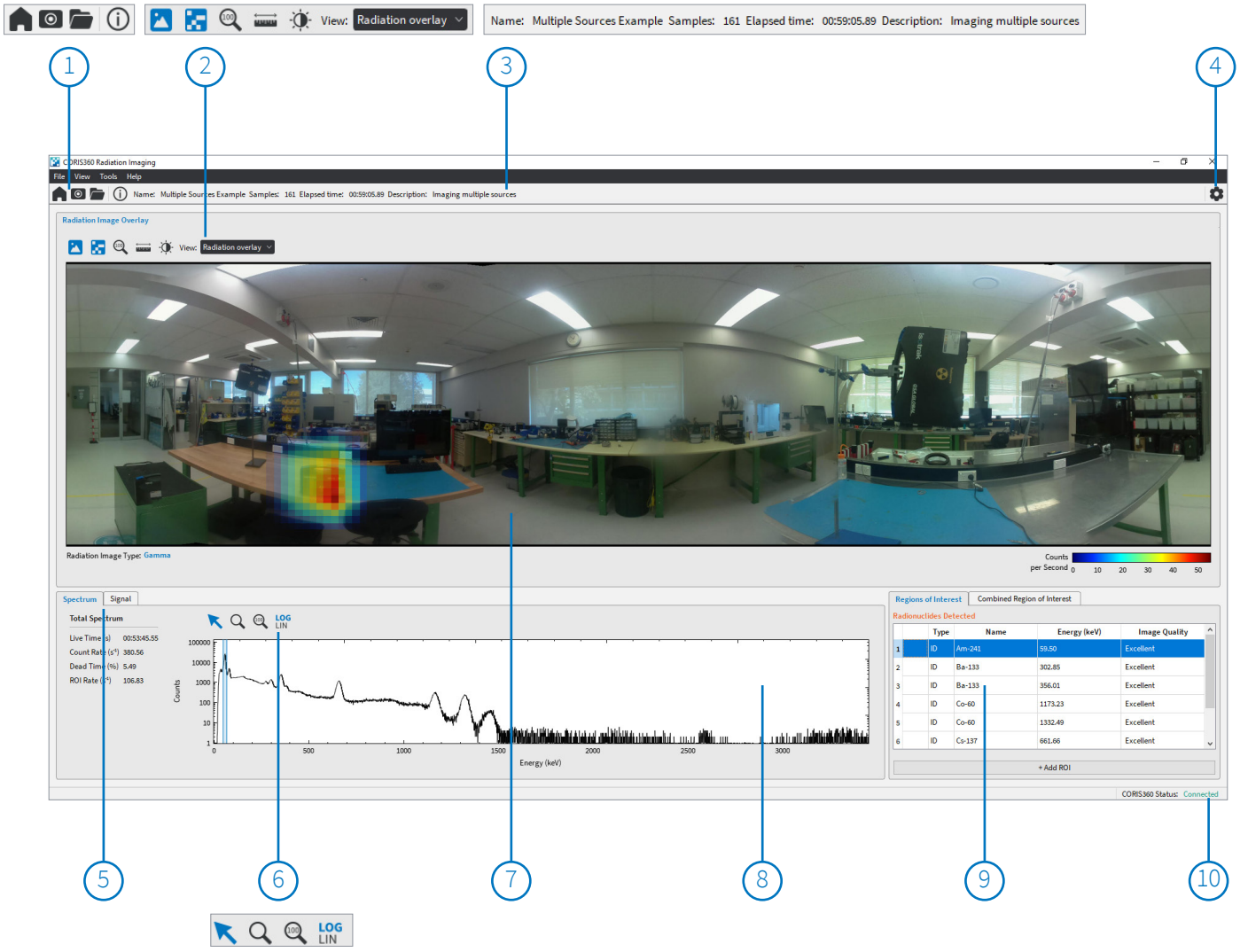
1. Start new image capture
2. Open previously saved image capture stored on computer
3. Download previously saved image capture stored on CORIS360® device
4. View currently acquiring image capture after software was closed and re-opened

New Image Capture Window



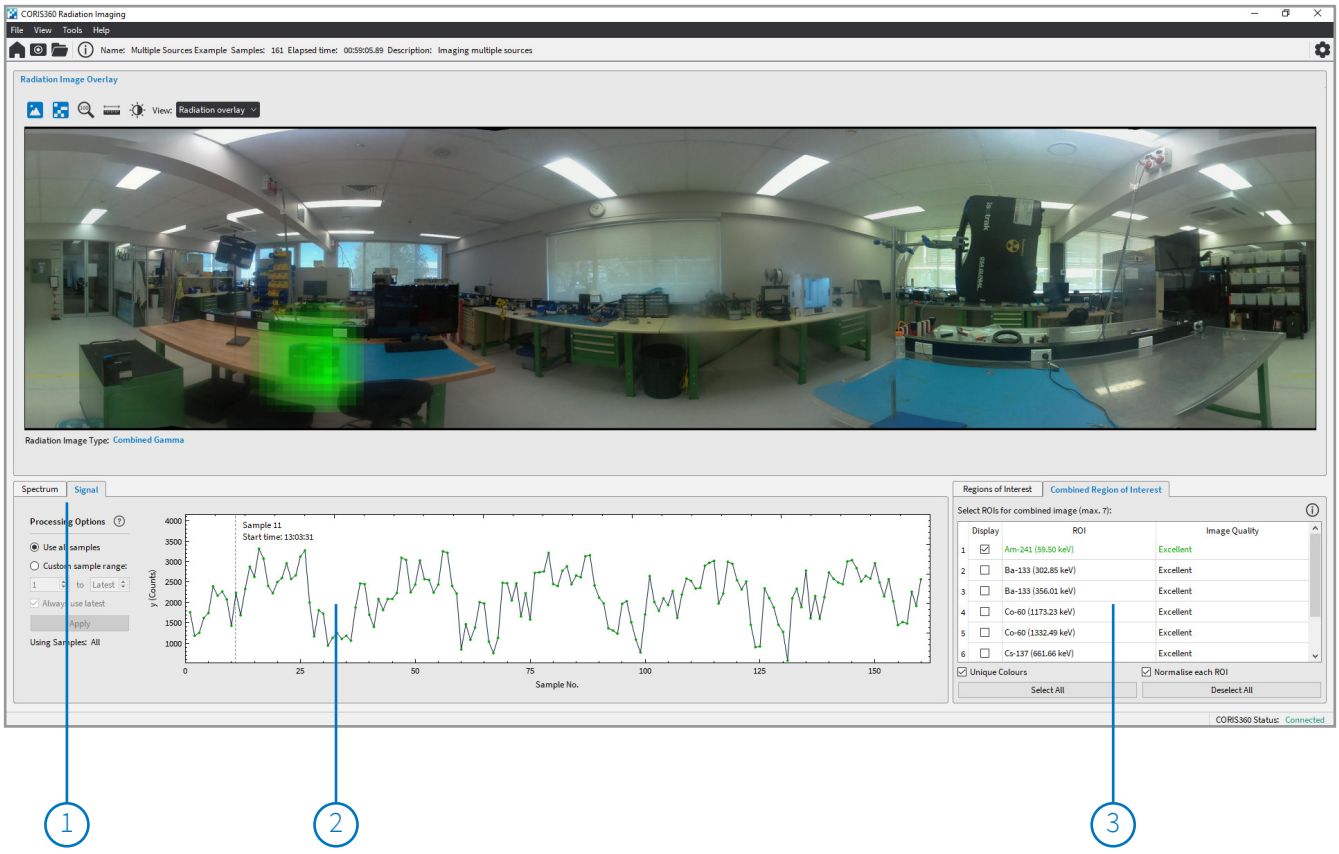
1. Length of time data will be acquired for each individual sample
2. Name of current image capture
3. Location where image capture is occurring (optional)
4. Name of operator performing the image capture (optional)
5. Help button to assist with selecting correct sample time
6. Advanced options to enable/disable optical panorama and schedule image capture
7. Brief description of current image capture scenario (optional)
8. Close New Image Capture window
9. Start the image capture

Main Window (With Spectrum and Regions of Interest Tab)



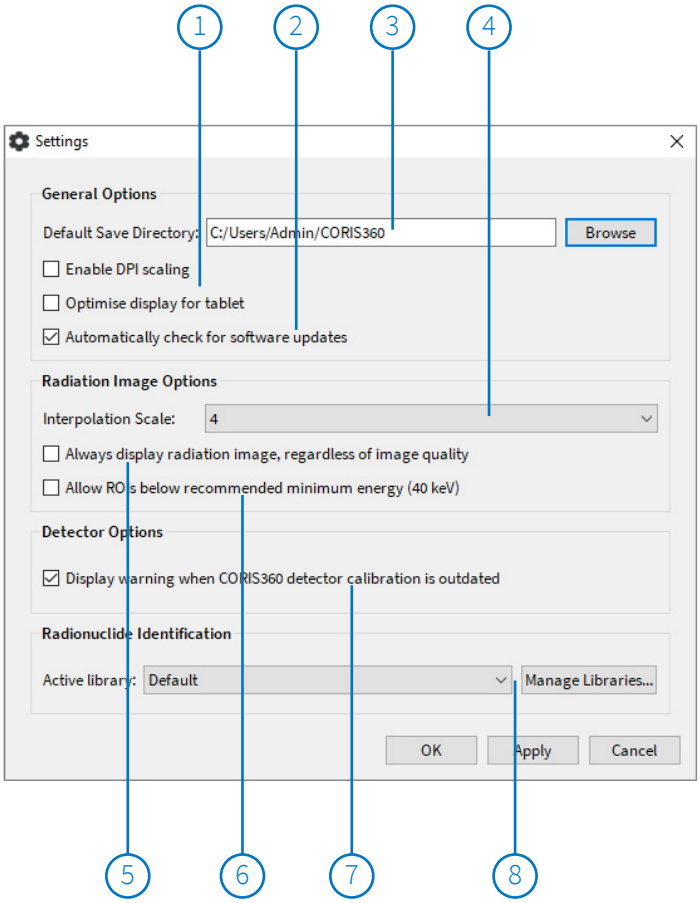
1. Toolbar buttons
2. Radiation image overlay buttons
3. Summarised image capture information
4. Settings button
5. Change between spectrum/signal tabs
6. Spectrum buttons
7. Gamma/Optical image overlay
8. Spectrum (displaying counts per gamma-ray energy)
9. Regions of Interest table
10. CORIS360 Status

Main Window (With Signal and Combined Region of Interest Tab)



1. Change between spectrum/signal tabs
2. Signal (displaying counts per sample number)
3. Combined Region of Interest table

Settings Window



1. Enable/Disable display settings to optimise dots per inch (DPI) scaling or for tablet device
2. Enable/Disable automatic check for software updates
3. Default location where data is automatically saved at end of image capture
4. Changes the interpolation scale of the reconstructed radiation image
5. Enables/Disables ability to view radiation image even when image quality is bad
6. Enables/Disables ability to create ROI's below 40 keV
7. Enables/Disables outdated detector calibration warning
8. Change, manage and customise active library for radionuclide identification

Toolbar Buttons Explained


Open home window


Start new image capture


Load previously saved image capture stored on computer


Display detailed information on current image capture

Radiation Image Overlay Buttons Explained


Toggle optical image between colour and greyscale to improve gamma image clarity


Toggle gamma image pixel interpolation on/off

Reset the zoom of the panorama to full-scale (mouse scroll wheel can zoom in/out)


Set the distance from CORIS360® to the suspected radiation source. As the radiation detector and optical cameras are not at the same location in space, some optical/radiation image parallax error is unavoidable. This can be compensated for by inputting the approximate distance to the suspected radiation source. In practice, parallax effects are negligible except at distances less than ~1–2 m. As such, setting the distance correctly is more critical for close-up imaging


Adjust the brightness and contrast of the optical panorama, or replace it with another panorama. Any optical panorama changes that are made can be reverted back to the original panorama that was taken during the initial image capture.

Spectrum Buttons Explained


Set cursor mode on spectrum tab. In cursor mode the user can:

- Click and drag right to zoom in
- Click and drag left to reset zoom
- Right-click to add an ROI at the cursor position

In cursor mode and while adding an ROI the user can:

- Double click to set ROI centroid
- Click and drag ROI marker lines


Set zoom mode on spectrum tab. In zoom mode, clicking on the spectrum will zoom in on the cursor location

Reset the zoom of the spectrum to full-scale (mouse scroll wheel can also zoom in/out)

Toggle the spectrum y-axis between logarithmic and linear scale

4.2. Start an Image Capture

To start a new image capture, follow the steps below:

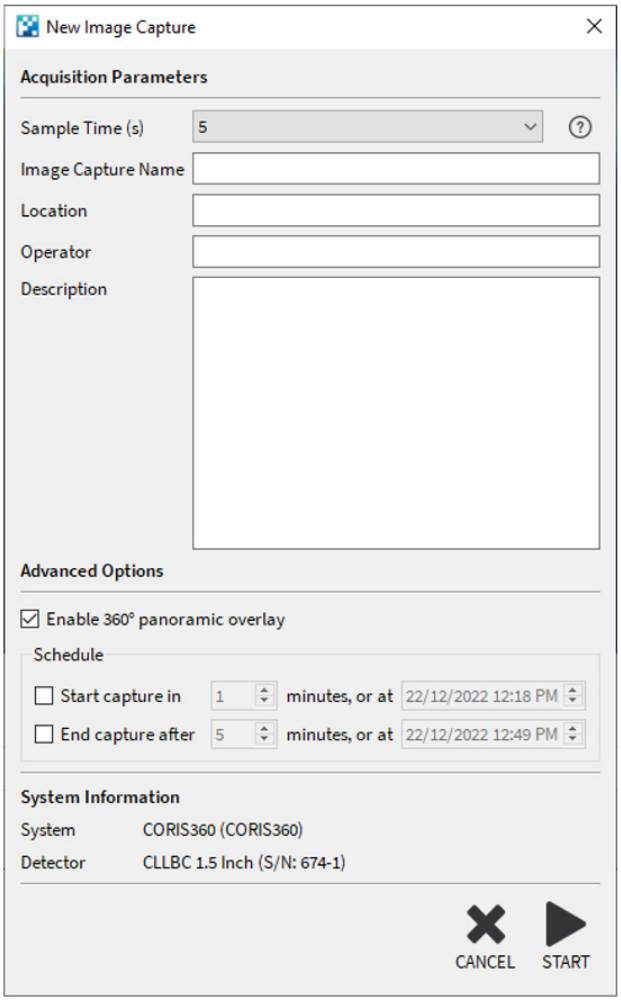
> ***WARNING.*** *Operating the system in wet conditions can result in electric shock. To avoid this, ensure the system is only operated in dry conditions in accordance with IP54 rating.*

> ***CAUTION.*** *Operating the system outside of the operating temperature range can damage the system and decrease performance. To avoid this, ensure the system is only operated inside the operating temperature range.*

1. If not previously installed, install the **CORIS360® Radiation Imaging** software using the steps in Section 2.7.
2. Connect CORIS360® to mains power and the computer using the provided cables and Wi-Fi dongle.
3. If not done previously, insert one of the provided detectors into the system using the steps in Section 2.6.

NOTE. The CLLBC15 (red) detector is recommended in most scenarios due to its greater detection efficiency, resulting in significantly faster detection and imaging times. The CLLBC05 (blue) detector should be used in higher dose rate (> 2 mSv/h) environments.

4. Open the installed software. A shortcut will be present on the computer desktop after the installation.
5. Turn the system on by pushing the power button. The button will light up green.
   a. The system will then initialise for < 1 min. Initialisation is complete when the ***CORIS360 Status*** in the bottom right corner of the software window reads ***"Connected"***.
6. Press the ***New Image*** button, opening the ***New Image Capture*** window (shown on the right).



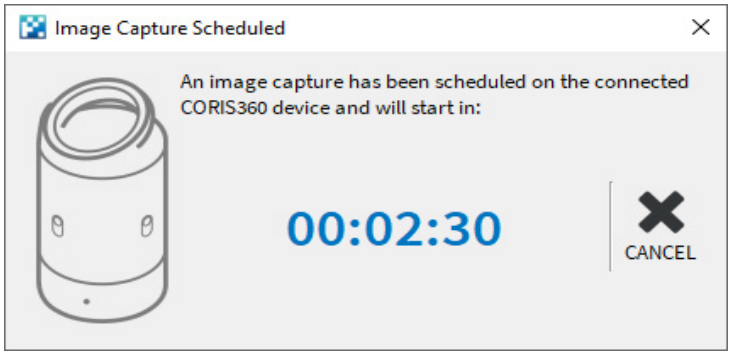
7. In the ***New Image Capture*** window, a ***Sample Time*** must be selected and an ***Image Capture Name*** must be entered, with the rest of the fields optional.
    a. The ***Sample Time*** is the length of time (in seconds) that data will be acquired for each individual sample (the time in each mask position). **A sample time of 5 s is a suitable value for most gamma imaging scenarios**. For low dose environments, however, this value should be increased. The two tables below provide a rough guide for the sample times required for various gamma dose rates for both the CLLBC05 and CLLBC15 detectors, respectively. See Section 5.1 for further information on selecting the optimal sample time.

Dose Rate (µSv/h)	Dose Rate (mRad/h)	CLLBC05 Detector (blue) Sample Time (s)	CLLBC15 Detector (red) Sample Time (s)
< 0.5	< 0.05	120+	30 – 60+
0.5 – 1	0.05 – 0.1	60 – 120	10 – 30
1 – 2	0.1 – 0.2	20 – 60	5 – 10
2 – 5	0.2 – 0.5	10 – 20	3 – 5
5 – 10	0.5 – 1	5 – 10	2 – 3
> 10	> 1	2 – 5	1 – 2

NOTE. Longer sample times will always produce better results, but the image acquisition will take longer.

NOTE. The sample time is NOT the total image capture time, but rather the time for each individual sample (the time in each mask position). The total image capture time is (sample time) × (no. samples).

    b. The ***Image Capture Name*** is the name the user gives to the current image capture and will be the name used when saving the results.
    c. The ***Location***, ***Operator*** and ***Description*** fields are all optional and can be used to include more descriptive information about the current image capture.
    d. The ***360° panoramic image*** check box sets whether the user wants to take an optical image as well as a gamma image (checked), or just the gamma image (unchecked).
    e. The ***Schedule*** check boxes allow the user to delay the start time of the image capture or set the image capture to finish at a certain time.
    f. It is highly recommended that the user reads Section 5.1 of this manual which provides detailed instructions and tips on selecting the optimal ***Sample Time*** and how many samples to acquire.
8. After all necessary fields are completed, press the ***Start*** ▶ button.
9. CORIS360® will begin the image capture and start taking samples.
    a. If the ***Schedule*** check box was checked to delay the start of the image capture, a countdown timer window will appear (shown on the next page) displaying the time remaining before the image capture starts.



10. Once the image capture has started, counts will begin accruing in the ***Spectrum*** tab at the bottom of the software window.
    a. The four optical cameras will take photos of the scene and create a 360° panorama (if the ***360° panoramic image*** box was checked). During this time, it is best practice to ensure nothing is moving in the field of view of CORIS360® to avoid any image artefacts. The optical image will then be displayed once the individual images have been stitched together to create the panorama. The centre of the panorama represents the front of CORIS360®.
    b. The device will continue acquiring data until either the ***Stop*** ■ button is pressed, the image capture was scheduled to end at a certain time or CORIS360® has acquired 1024 samples.

NOTE. The optical panorama can be retaken at any point while the image capture is still acquiring data by clicking Tools > Retake Optical Images from the menu bar at the top of the main window.

11. Only the optical image will be displayed initially.
12. If a peak is identified through the software's automatic radionuclide identification, the gamma image for that peak will be overlaid onto the optical image once it achieves an image quality above ***"Insufficient Data"***.

NOTE. The software also has an in-built neutron detection alarm due to the detectors having a dual gamma and thermal neutron response. When neutrons are detected, a window will appear notifying the user.

13. If no peak is automatically identified, a region of interest (ROI) must be added to produce the overlaid gamma image. To add a custom ROI, follow the steps in Section 4.3.
14. To complete the image capture, press the ***Stop*** ■ button or wait for CORIS360® to acquire all 1024 samples. The data will be saved automatically on the computer in the user's home directory as a .c360 file (the automatic save location can be changed through the ***Settings*** ⚙ button on the main window).
    a. The automatically saved .c360 file will have a filename consisting of the image capture name, the file ID number and the serial number of the CORIS360® device.
    b. To save the data to a different location, click ***File > Save As…*** from the menu bar in the top left of the window and follow the prompts.
    c. Saved data can be loaded back into the software at a later date for further analysis and to generate a report of the results.
15. After the image capture is complete, the masks will rotate back to their home position, ready for the next capture.

NOTE. When an image capture has completed, the data is also automatically saved on CORIS360® itself. This allows for the data to be viewed on any computer by downloading the data from CORIS360®.

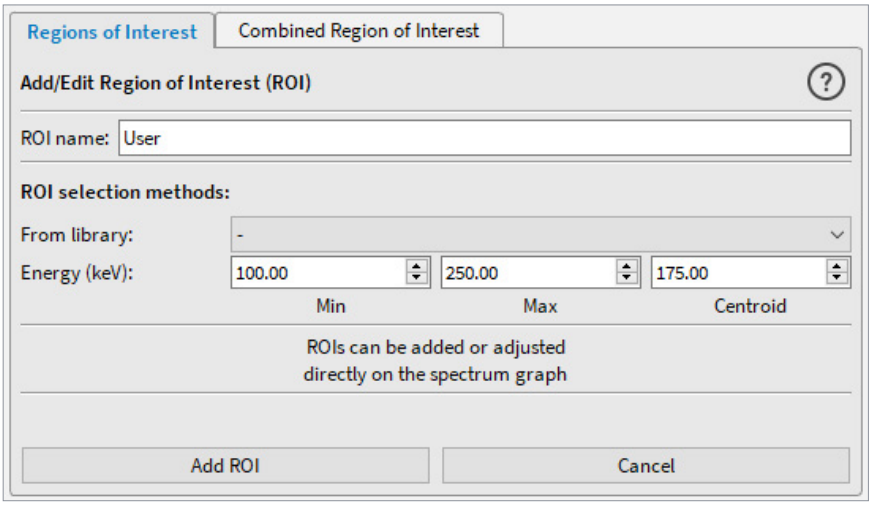
4.3. Adding a Region of Interest (ROI)

The **CORIS360® Radiation Imaging** software contains an automatic radionuclide identification feature. This feature identifies peaks in the spectrum and automatically adds them to the ***Regions of Interest*** (ROI) table, along with their corresponding name and energy. The fully customisable radionuclide library contains 15 common radioisotopes by default (see Section 4.8 for steps on how to customise the library). When a peak is automatically identified, it will have type ***" ID "*** in the ROI table. ROI's of type ***" ID "*** cannot be edited or deleted.

Following the automatic radionuclide identification, the user may want to add a custom ROI. Reasons for adding a custom ROI could include adding a peak in the spectrum which was not automatically identified or wanting to image over a non-peak region in the spectrum (see Section 3.3 and the **X-Ray Example**). To add a custom ROI, follow the steps below.

NOTE. All ROI's are saved when an image capture is saved. These ROI's will then be loaded back into the ROI table when re-opening an image capture. This allows for any previous data analysis to be saved, stored and re-opened for future use.

1. From the main window in the software, ensure you have selected the ***Regions of Interest*** tab and click the ***+ Add ROI*** button in the ***Regions of Interest*** tab at the bottom right of the screen, displaying the tab shown below.
   a. The user can also add an ROI by right-clicking on the spectrum and selecting ***Add ROI***.



2. Enter a name for the ROI or use the default name provided.
3. The ROI can then be set using any of the following methods:
   a. Select a pre-defined peak from the dropdown library.
   b. Enter either a minimum and maximum energy range for the ROI or enter the centroid energy for the ROI.
   c. Using the spectrum on the left, double-click the spectrum to centre the ROI at a specific energy. This will also automatically set the width of the ROI.
   d. Using the spectrum, click on each of the red ROI marker lines and drag them to the desired minimum and maximum energies.

NOTE. The ROI help button ⓘ can also be used to provide further information on how to add a ROI.

4. Once the ROI has been set, click ***Add ROI*** and the reconstructed gamma image for the selected ROI will be overlaid onto the optical image once it achieves an image quality above ***"Insufficient Data"***.
5. Multiple ROI's can be added by repeating Steps 1 – 4. The gamma image being overlaid on the optical image can be alternated by selecting different ROI's in the table.
6. ROI's added using the above method are manually entered ROI's and have type ***"User"***.
   a. Only ***"User"*** ROI's can be edited or deleted. To edit or delete a ***"User"*** ROI, press the ***Edit*** button.
7. The final column in the ROI table, titled ***Image Quality***, indicates the quality of the reconstructed image for the selected ROI. This column is the primary indicator of the accuracy and reliability of the gamma image. For a description of each ***Image Quality*** level and a deeper explanation of how to interpret the image quality, see Section 5.1.

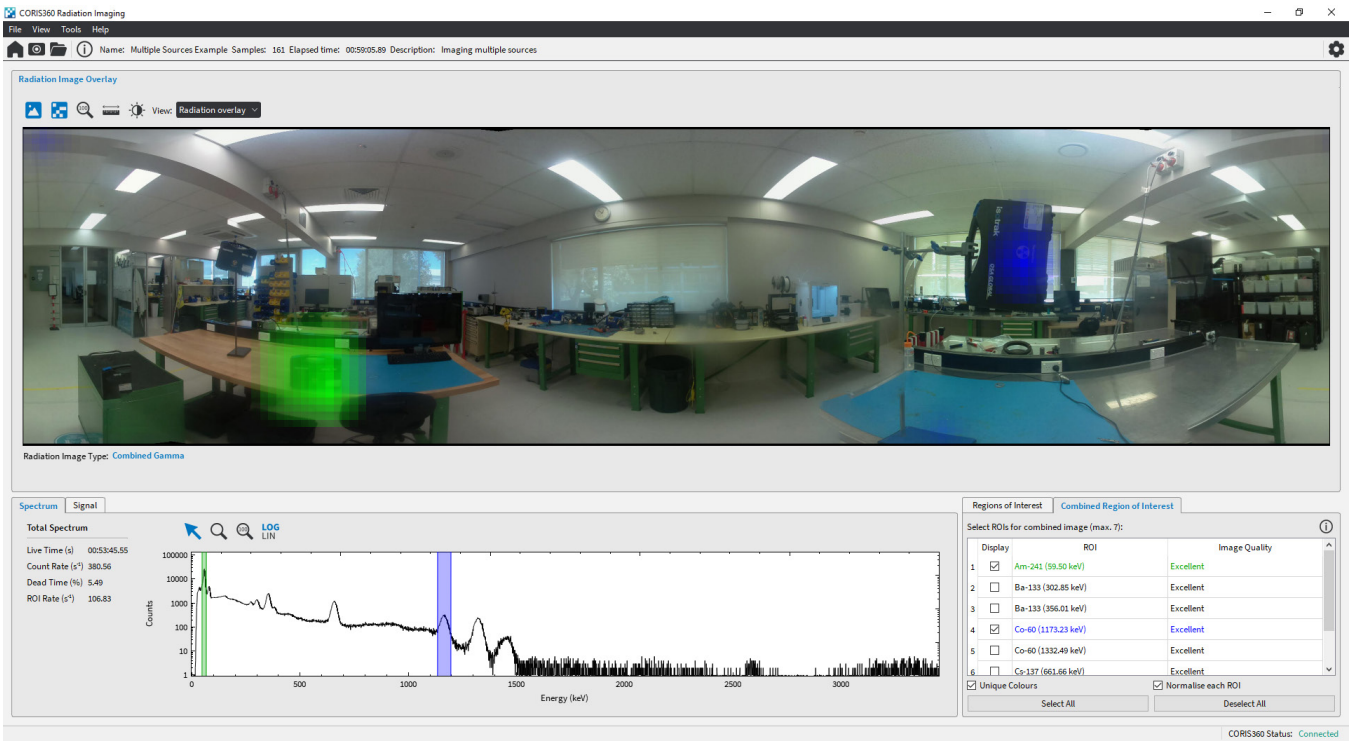
CORIS360® has the ability to image over both peak and non-peak energy ranges in the spectrum. **If custom ROI's are added following the radionuclide identification, a practical first choice is to add a ROI around any visible peaks in the spectrum that were not automatically identified. Double-clicking the centre of any visible peaks is the recommended method for adding a custom ROI as the software will automatically set an accurate width for the ROI**.

If no peak is visible, but a significant number of counts are present in the spectrum, it is possible a gamma emitting radionuclide may be present behind some form of shielding. This shielding could either be environmental (i.e. through a building wall) or through intentional masking. In this case, it is sensible to set the ROI to a wide range of the spectrum (e.g. 100 – 200 keV) to create a gamma image using scattered radiation.

For further instructions on how to select a practical ROI, see Section 5.2.

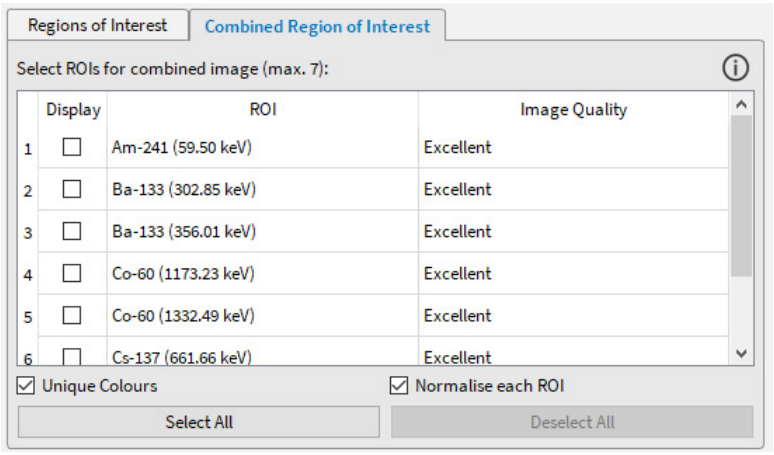
4.4. Adding a Combined Region of Interest (CROI)

Once ROI's have been added to the ROI table, the **CORIS360® Radiation Imaging** software provides the ability to show multiple ROI's on the same radiation image overlay using the ***Combined Region of Interest*** (CROI) tab. This can be a visually effective way of displaying multiple radiation sources and their corresponding locations all on the one optical panorama, as can be seen in the image below.



The CROI table contains a list of the ROI's that have already been added, with both automatically identified and custom ROI's being included. By toggling the ***Display*** check boxes in the CROI table, the user can display any combination of ROI's at the same time.

NOTE. A maximum of 7 ROI's can be displayed at any one time in the CROI tab.



While the ***Unique Colours*** check box is checked, each checked ROI will have a unique colour assigned to it, with this colour also being used to mark the corresponding radiation image hot spot and ROI in the spectrum. When the ***Unique Colours*** check box is unchecked, the radiation image hot spot for each ROI will no longer have a unique colour but will instead all use the software default colour map.

If the ***Normalise each ROI*** check box is checked, the radiation image hot spot for each ROI will first be scaled by its maximum count rate, and then combined. Despite potentially large count rate differences between the individual ROI's, the radiation image hot spot for each ROI will display with the same visual intensity. This is useful for determining the location of multiple radioactive sources, where the intensity of each source is not important. If this check box is not checked, the radiation image hot spot for each ROI will be scaled by the maximum count rate of all the ROI's (detector efficiency not taken into account). This method of displaying the data provides a more accurate interpretation of the relative count rate intensities between each of the ROI's.

4.5. Open, Download or View Current Image Capture

The ***Open Image*** button is used to load a previously saved image capture stored on the computer. To use this button, follow the steps below:

1. If not done previously, open the **CORIS360® Radiation Imaging** software.
2. Click the ***Open Image*** button either from the home window, from the top left corner of the main window or by using the shortcut ***Ctrl+O***.
3. Navigate to the desired image capture and select ***Open***.
4. The previously saved image capture will then be loaded from the computer and ready for analysis or data exportation.

The ***Download from CORIS360*** button is used to load a previously saved image capture stored on the CORIS360® device itself. Once an image capture is completed, the data will be automatically saved to both CORIS360® and to the computer CORIS360® is connected to. This button would be used in scenarios where, for example, a new computer is being used with CORIS360® and the user wants to look at a previous image capture obtained on the device. By clicking the ***Download from CORIS360*** button, this previous capture can be loaded from CORIS360® and viewed on the connected computer. To use this button, follow the steps below:

1. If not done previously, open the **CORIS360® Radiation Imaging** software and connect the computer to CORIS360® using the provided Ethernet cable or Wi-Fi dongle.
2. Click the ***Download from CORIS360*** button from the home window, opening the ***Download Image Data from CORIS360*** window.
3. Using this window, select the image data to be loaded and click ***Download***. The user is also able to delete any image data stored on CORIS360® when in this window.
4. The saved image capture will then be loaded onto the connected computer ready for analysis or data exportation. The image capture can also now be saved directly to the computer.

The ***View Current Image Capture*** button is used to view an image capture that is currently acquiring data on CORIS360®. This button would be used in scenarios where, for example, the user opens a previous image capture or the software is closed then re-opened, both while the device is still acquiring. In both examples, the device will continue acquiring data as normal, and the user can return to this capture by clicking the ***View Current Image Capture*** button. To use this button, follow the steps below:

1. If not done previously, open the **CORIS360® Radiation Imaging** software and connect the computer to CORIS360® using the provided Ethernet cable or Wi-Fi dongle.
2. Click the ***View Current Image Capture*** button from the home window, or in the top right corner of the main software window.
3. The image capture currently acquiring data on CORIS360® will then be shown on the software's main window and will continue acquiring as normal.

NOTE. Once an image capture has begun, the Ethernet cable can be unplugged, or the Wi-Fi disconnected, from CORIS360® and the image capture will continue to run as normal. To stop the image capture or communicate with the device for any reason, the Ethernet cable must be plugged back in, or the Wi-Fi reconnected.

4.6. Using the Spectrum and Signal Tabs

Using the **CORIS360® Radiation Imaging** software, the user has the ability to obtain much more information on the image capture results through the ***Spectrum*** and ***Signal*** tabs on the main window. The ***Spectrum*** tab is shown initially by default. From this tab the user is able to view and manipulate the spectrum using either the cursor or the spectrum buttons. For detailed information on the function of the ***Spectrum*** buttons and how to manipulate the spectrum, see Section 4.1. Selecting a different ROI from the ROI table will display the location of the selected ROI on the spectrum. In addition, placing the cursor in the spectrum plot will inform the user of the energy and number of counts at that energy for the current cursor position. The tab also provides a variety of spectrum information regarding the current image capture. An explanation of this information is provided below:

Live Time (s)	Refers to the total time the detector was recording counts. This differs to the elapsed time, which is the total time the image capture has been acquiring for. The live time can differ due to an intrinsic property of detectors which require a fraction of a second to recover after a photon of radiation hits the detector. This difference between live time and elapsed time can differ significantly for a large amount of incident photons (large dead time).
Count Rate (s^{-1})	The number of photons being counted by the detector per second.
Dead Time (%)	Represents the percentage of time that the detector was "dead" (i.e. not recording counts).
ROI Rate (s^{-1})	The count rate for only the region of the spectrum within the selected ROI.

By clicking the ***Signal*** tab, the user is provided with information regarding the number of counts CORIS360® is acquiring per individual sample. This tab therefore allows the user to determine whether they are acquiring enough counts per sample to produce an accurate gamma image. It is recommended that the user reads Section 5.1 for a more detailed understanding of the required number of counts per sample. Changing the selected ROI from the ROI table changes the plot in the ***Signal*** tab, allowing the user to check that they are acquiring enough counts for all ROI's. In addition, placing the cursor in the signal plot will inform the user of the sample number of counts in that sample and the sample start time for the current cursor position. The tab also provides various processing options, providing the user with the ability to change the sample range that is currently being used to calculate the gamma image. This feature is useful in scenarios where, for example, the gamma source of interest was moved or altered during an image capture. By using the custom sample range feature, the user is able to exclude samples consisting of bad data from the beginning or end of a capture instead of having to discard and repeat the entire image capture. Utilising this custom sample range feature also allows the user to perform time lapsed imagery, providing the ability to view the movement of a source by imaging over different sample ranges. An explanation of the processing options is provided below:

Use all samples	Calculates the gamma image using all completed samples.
Custom range	Calculates the gamma image using a custom range of completed samples.
Always use latest	Check box which calculates the gamma image using a custom range of completed samples, and when checked, adds the latest completed sample to the end of the custom range used for the calculation. This check box is useful when an image capture is still acquiring data.

4.7. Generating a Report, Exporting Data and Reporting a Problem

Once an image capture has completed, the ***CORIS360® Radiation Imaging*** software provides the ability to export the results from the image capture into a zip file containing the data for external analysis. A description of each file contained in the exported zip file is given below:

4 Raw Optical Images	The raw, unstitched optical images from the 4 cameras in CORIS360®.
Optical Panorama	The optical panorama made from the 4 raw optical images stitched together. The gamma image is overlaid on top of this stitched photo in the software.
Export Information .txt file	A text file containing all of the essential image capture information such as the capture name, sample time and number of samples, detector calibration parameters and the start and end time of the capture.
Export Sample Timing .csv file	A csv file containing live time, real time and dead time information for each individual sample.
Export Spectra .csv file	A csv file containing the number of counts in each energy bin of the spectrum for each individual sample. Each row in this file is an individual sample and each column is the number of counts in that energy bin.
Export Spectrum .csv file	A csv file containing the total spectrum for the entire image capture. This file is equivalent to the **Export Spectra** file if the counts in each energy bin were summed together for all samples. The first column in the file is the energy (in keV) and the second column is the number of counts at that energy.
Export Spectrum .n42 file	A n42 file containing the same information as the csv file of the same name, however the data is in a format that can be readily accessed in spectroscopy analysis software.
Export ROI Data .csv file	A csv file containing the data for the reconstructed gamma image for the given ROI. One of these files will be exported for every ROI present in the ROI table.
Export ROI Image .png file	A png file containing the reconstructed gamma image overlaid on the optical image for the given ROI. One of these files will be exported for every ROI present in the ROI table.

To export the data, click ***File > Export Data*** from the menu bar in the top left of the software window (or use the shortcut ***Ctrl+E***) and follow the prompts to save the data in the desired location.

The software also has the capability to output a summary of the results in the form of a report. The report contains all of the essential information from the image capture, including the capture name, elapsed time, sample time and number of samples, spectrum, image overlay and all of the ROI's in the ROI table. The user also has the ability to include any combined ROI's in the report, along with the option to exclude certain ROI's from the report using the advanced options. The first page of the report contains a summary of the image capture, with the remaining pages providing more detailed results on each of the ROI's. An example report is provided in Appendix C.

To generate a report, click ***File > Generate Report*** from the menu bar in the top left of the window and follow the prompts to customise and save the report in the desired location.

Lastly, the software also provides the ability to report a problem in the software in the unlikely event that one is encountered. To report a problem, click ***Help > Report a Problem*** from the menu bar in the top left of the software window. This will open a new email in the user's default mail application, addressed to *support@coris360.com*. Please provide as much information in the email as possible when reporting a problem so that we can rectify the issue as soon as possible.

4.8. Changing and Customising the Radionuclide Identification Library

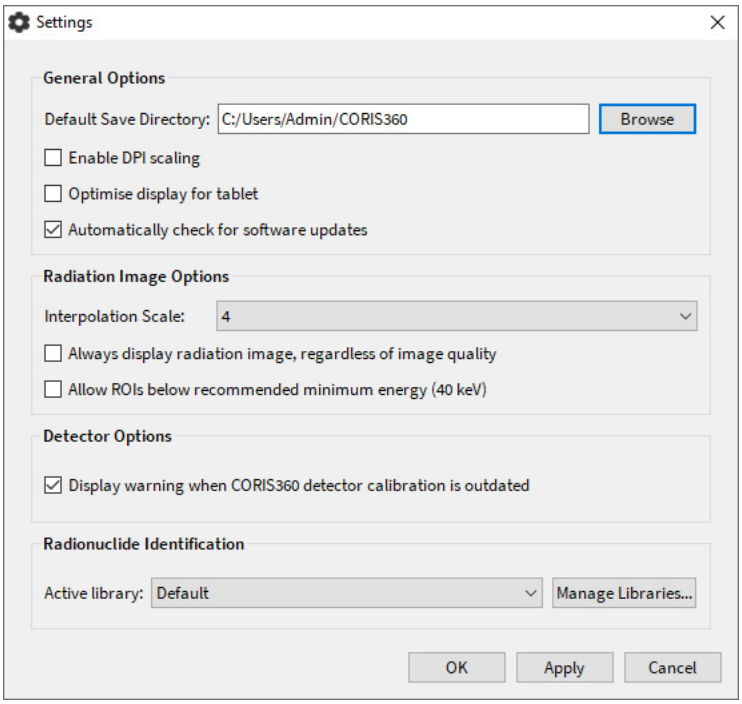
The software provides the user with the ability to change and create custom radionuclide libraries. These libraries are used by the automatic radionuclide identification feature of the software when fitting and assigning peaks in the spectrum. If a radioisotope is not contained in the active radionuclide library, it will not be assigned to any peak in the spectrum and will therefore not be identified.

The default radionuclide library contains 15 radioisotopes, which are listed in the table below. The default library cannot be edited or deleted.

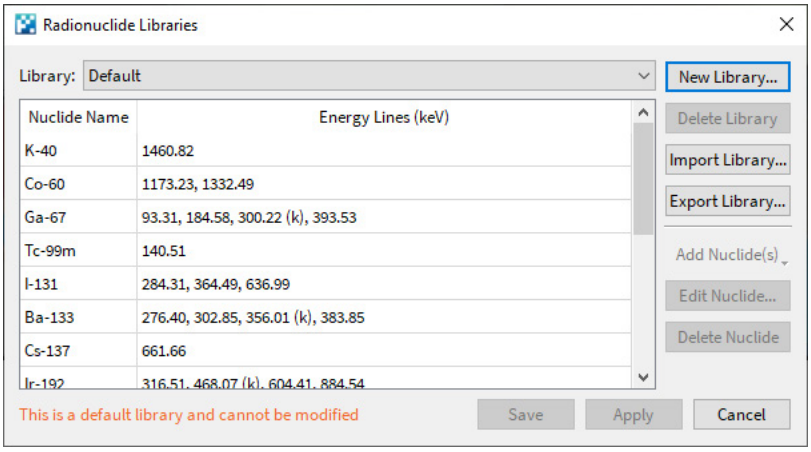
^{40}K	^{99m}Tc	^{137}Cs	^{226}Ra	^{238}U
^{60}Co	^{131}I	^{192}Ir	^{232}Th	^{239}Pu
^{67}Ga	^{133}Ba	^{201}Tl	^{235}U	^{241}Am

To edit, create and change radionuclide libraries:

1. If not done previously, open the **CORIS360® Radiation Imaging** software.
2. From the main window, click the ***Settings*** ✿ button to open ***Settings*** window (shown on the next page).



3. Next, click the ***Manage Libraries…*** button, opening the ***Radionuclide Libraries*** window (shown below).



4. From this window, the user is able to create a new library, import or export a library and edit an existing library.

NOTE. The default library cannot be edited or deleted. A new library must first be created before radionuclides can be added or modified.

5. After a custom radionuclide library has been created, click the ***Apply*** then ***Save*** buttons and close the ***Radionuclide Libraries*** window.
6. Then, to update the radionuclide library actually being used by the software, in the ***Settings*** window change the ***Active library*** to the desired library.
7. Lastly, click the ***Apply*** button, and the library being used by the software has now been updated.

5. UNDERSTANDING THE RESULTS

5.1. Image Quality Interpretation and Optimal Image Capture Parameters

As a general rule, the longer the sample time and the larger the number of samples, the better the quality of the data. However, having these values too large will result in an unnecessarily long image capture, and will negate one of the primary advantages of CORIS360®, its rapid identification and imaging speed. Therefore, a balance of time and quality of data must occur when selecting the optimal image capture parameters.

Selecting the correct sample time is essential for the optimal operation of CORIS360®. The choice of sample time is highly dependent on the total number of counts per sample for the ROI/s that the user wants to analyse. Lower dose/count rate environments will require longer sample times while higher dose/count rate environments will require shorter sample times. **It is best practice to ensure that for every ROI the user wants to analyse, the sample time is long enough such that the average number of counts per sample is at least 100 counts**. This value can be easily determined by selecting the ***Signal*** tab at the bottom of the main window in the **CORIS360® Radiation Imaging** software (see Section 4.6 for more information on the ***Signal*** tab). The two tables from Section 4.2 have been repeated below to provide a rough guide for the sample times required for various gamma dose rates for both the CLLBC05 (blue) and CLLBC15 (red) detectors.

Dose Rate (µSv/h)	Dose Rate (mRad/h)	CLLBC05 Detector (blue) Sample Time (s)	CLLBC15 Detector (red) Sample Time (s)
< 0.5	< 0.05	120+	30 – 60+
0.5 – 1	0.05 – 0.1	60 – 120	10 – 30
1 – 2	0.1 – 0.2	20 – 60	5 – 10
2 – 5	0.2 – 0.5	10 – 20	3 – 5
5 – 10	0.5 – 1	5 – 10	2 – 3
> 10	> 1	2 – 5	1 – 2

Once an acceptable sample time has been chosen, the next step is to stop the image capture once the correct number of samples have been completed. The number of samples required is primarily dependent on the complexity of the scenario being imaged, meaning the number of hot spots present in the image. **For more complex scenarios, more samples will be required**. A point source (one hot spot), for example, may require only 30 samples to be accurately imaged. A more complicated scenario (such as an extended source or many hot spots) would require further samples. The maximum number of samples CORIS360® will perform is 1024, however the user will almost never need to complete this full set of samples.

To provide feedback to the user on when enough samples have completed, information on the image quality is provided in the ROI table for each ROI. **The *Image Quality* column in the ROI table is the primary indicator of the accuracy and reliability of the gamma image**. A description of each ***Image Quality*** level is provided on the next page.

…	Indicates that the quality of the gamma image is still being processed.
Insufficient Data	Indicates that the gamma image is not accurate, and more samples are required.
Low	Indicates that the gamma image is nearing an accurate image, but more samples are recommended.
Good	Indicates that the gamma image is likely an accurate image and more samples will improve the accuracy.
Excellent	Indicates that the gamma image is highly likely an accurate image and more samples will continue to confirm the accuracy.

NOTE. It is recommended that more samples be acquired until the gamma image for a ROI achieves an image quality of at least "Good".

In low gamma dose/count rate environments, scenarios can exist where, for a given sample time, no number of further samples will produce an accurate gamma image. In cases such as this, the two best options are to either increase the sample time or move closer to the suspected location of the source, then start a new image capture. A good indication that this scenario is occurring is when the ROI the user wants to analyse has fewer than 100 counts per sample on average.

It should be noted that for these low dose/count rate environments, it may be necessary to acquire data for a very long time, ranging from several hours to days. **When trying to obtain a more accurate gamma image, it is generally more beneficial to increase the sample time rather than acquire more samples**. This is especially true in scenarios with few hot spots.

5.2. Selecting a Practical ROI

As detailed in Section 4.3, CORIS360® has the ability to image over both peak and non-peak energy ranges in the spectrum (see Section 3.3 for a demonstration of this capability). **If custom ROI's are added following the radionuclide identification, a practical first choice is to add a ROI around any visible peaks in the spectrum that were not automatically identified. Double-clicking the centre of any visible peaks is the recommended method for adding a ROI in this scenario since the software will automatically set an accurate width for the ROI**.

If no peak is visible, but a significant number of counts are present in the spectrum, it is possible a gamma emitting radionuclide may be present behind some form of shielding. This shielding could either be environmental (i.e. through a building wall) or through intentional masking. In this case, it is sensible to set the ROI to a wide range of the spectrum (e.g. 100 – 200 keV) to create a gamma image using scattered radiation.

When adding a custom ROI, the software may display a warning message at the bottom of the ***Regions of Interest*** tab. This message informs the user that their ROI selection is not good. Examples of poor ROI selections include:

- A ROI with no peaks (unless attempting to image scattered radiation).
- A ROI with low or zero counts (a warning will display if a region with very low counts is selected)
- Background or continuum energy ranges (i.e. the energy range between peaks in the spectrum).
- ^{40}K (Potassium-40), a common radionuclide present in the background in almost all locations. ^{40}K exhibits a peak at 1460 keV; this peak should not be used for imaging in most situations.
- ^{232}Th (Thorium-232), a common radionuclide present in the background in almost all locations. ^{232}Th exhibits a distinct peak at 2614 keV; this peak should not be used for imaging unless the user is very confident that ^{232}Th is present.

NOTE. If ROI warning messages are ignored and the ROI is still selected, the resulting gamma image will likely be inaccurate and unstable.

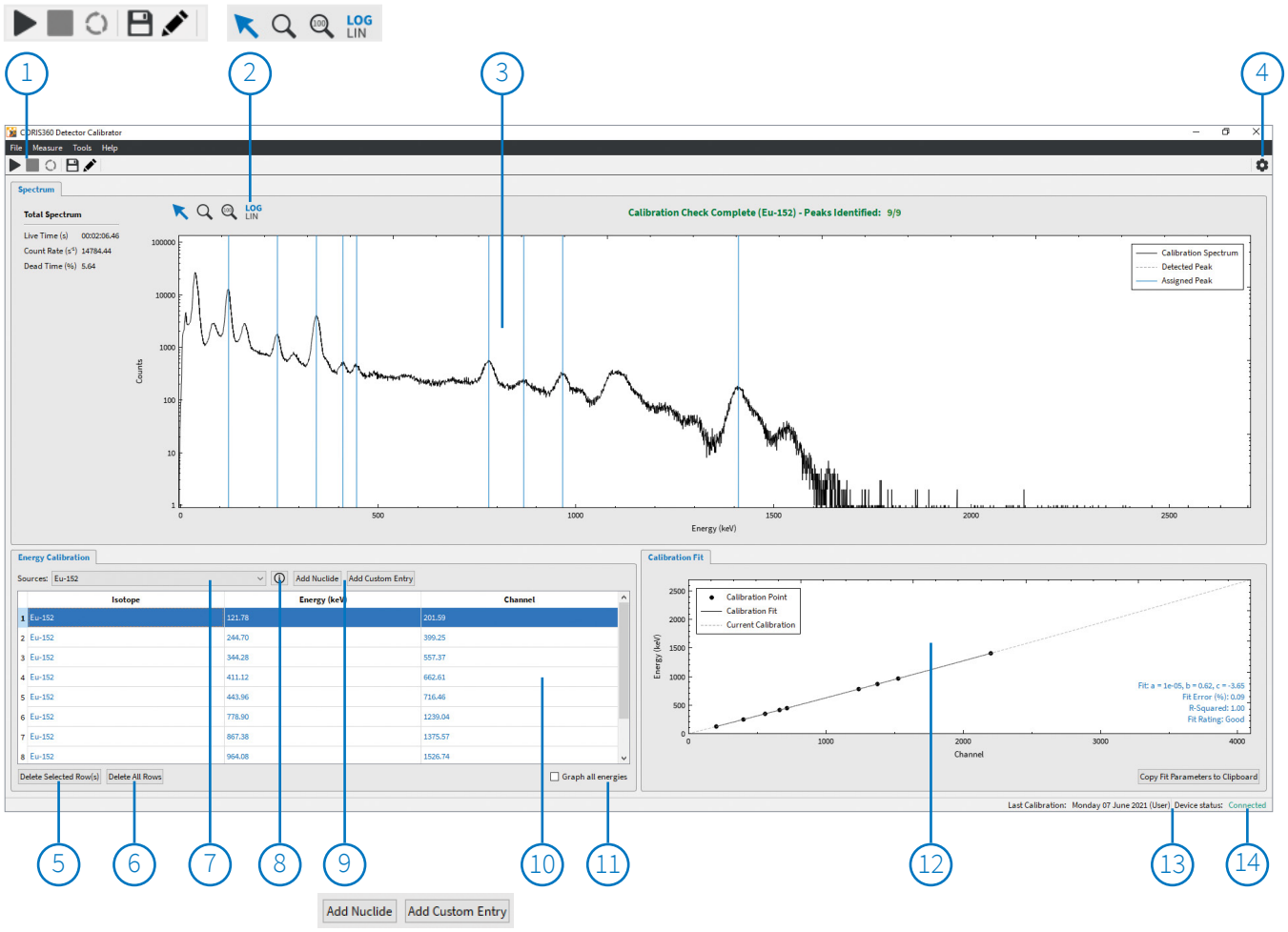
6. RE-CALIBRATING THE DETECTOR

The two detectors supplied with the system come pre-calibrated, with the calibration information stored on the detector. An unavoidable feature of gamma-ray detectors is that over time their calibration will slowly drift, requiring re-calibration. The detectors can be re-calibrated using the **CORIS360® Detector Calibrator** tool. This tool can be accessed through the **CORIS360® Radiation Imaging** software by clicking ***Tools > Open CORIS360 Detector Calibrator*** from the menu bar at the top of the software window. Alternatively, a shortcut to the tool was also created on the computer desktop during the initial CORIS360® software installation. The steps required to perform this calibration and the features of the calibration tool are detailed on the following pages.

NOTE. It is recommended that the calibration of the detectors is checked at least monthly. The CORIS360® Radiation Imaging software will remind the user when it has been a month since the last calibration.

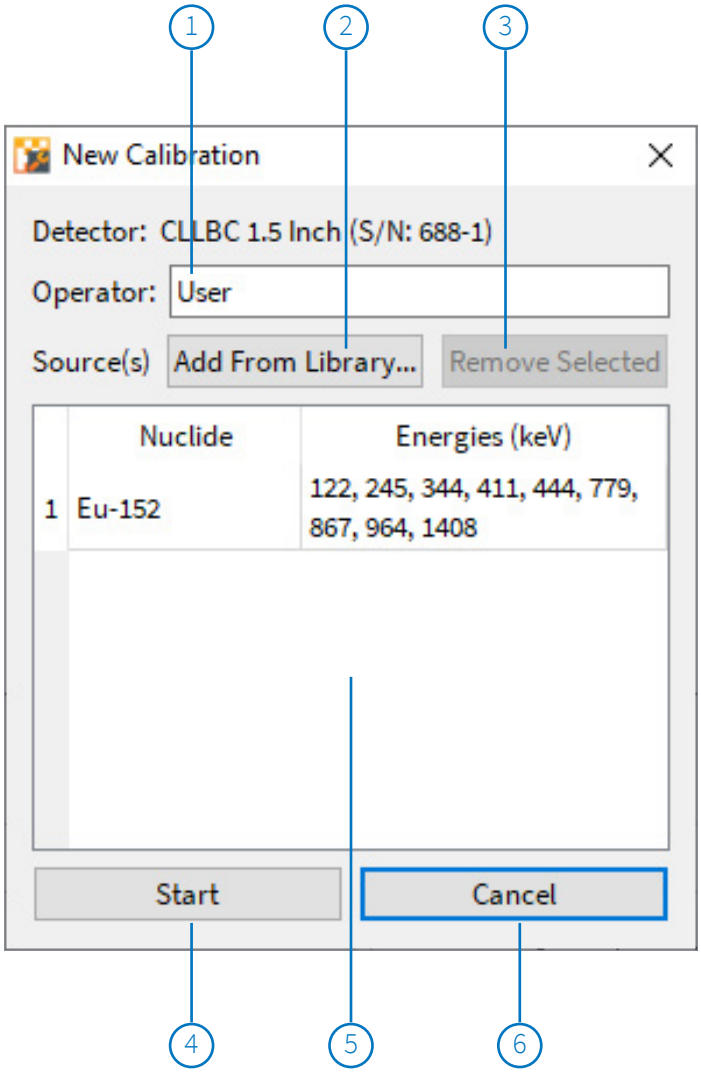
6.1. CORIS360® Detector Calibrator Features Explained

Main Window



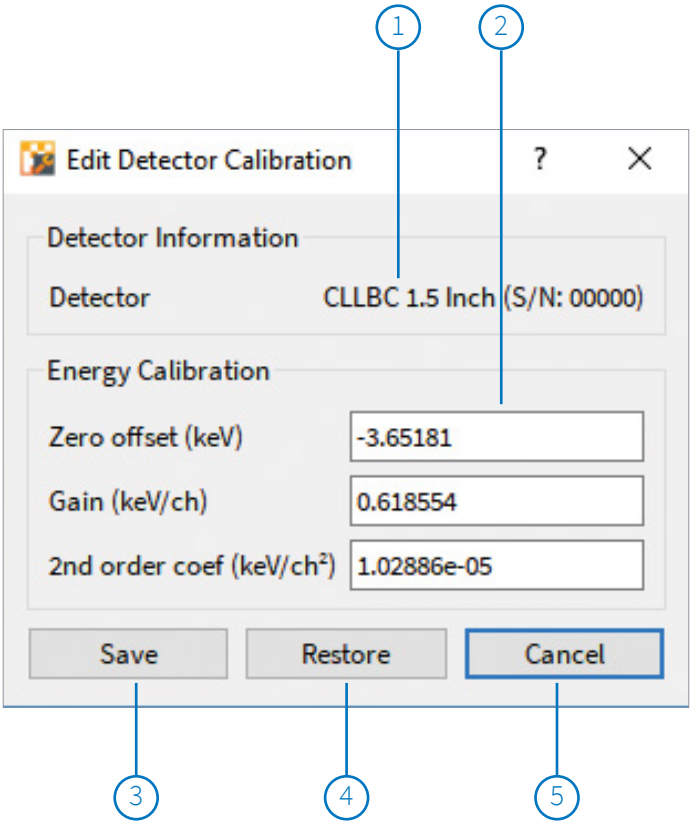
1. Toolbar buttons
2. Spectrum buttons
3. Spectrum (displaying counts per gamma-ray energy)
4. Settings button
5. Deletes selected row(s) from calibration table
6. Deletes all rows from calibration table
7. List of possible sources to add for energy calibration
8. Displays all main peak energies for selected source
9. Adds selected source in drop-down list (left button) or adds a blank row (right) to the calibration table
10. Energy calibration table
11. Displays all energies in the calibration table on the above spectrum
12. Calibration curve (displaying energy against channel)
13. Date of last calibration and CORIS360 status
14. Copies the calibration curve fit parameters (a, b, c) to the clipboard

New Calibration Window



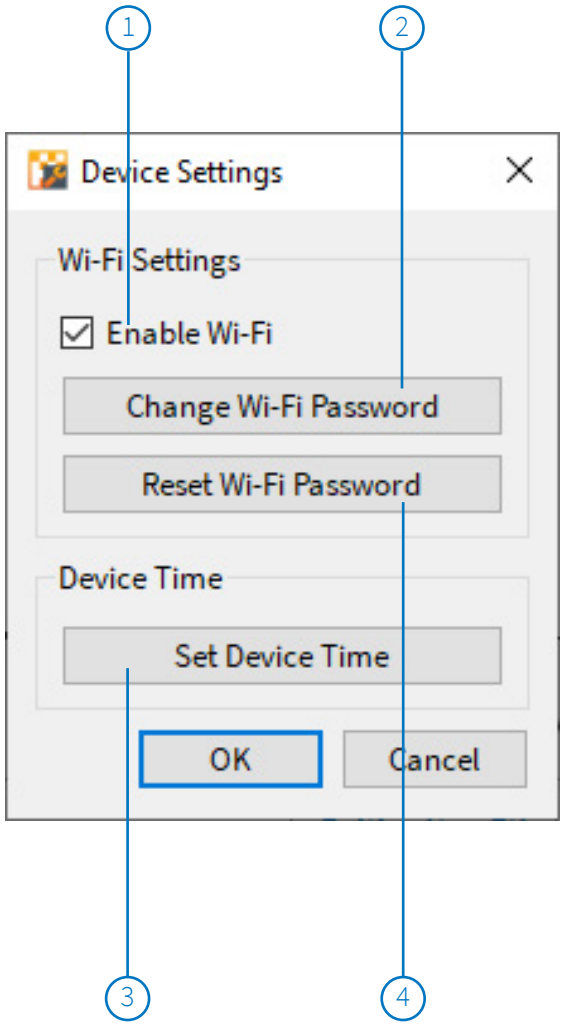
1. Name of operator performing calibration (optional)
2. Opens calibration source selection window to add/edit the sources in the table below
3. Removes selected source from table below
4. Starts the new calibration
5. Table of sources to be used for the calibration
6. Closes the new calibration window

Edit Detector Calibration Window



1. Name of detector
2. Energy calibration factors (a, b, c)
3. Saves current values to the detector
4. Restores all values in the window with the values currently saved on the detector
5. Closes the edit detector calibration window

Device Settings Window



1. Enables/Disables Wi-Fi. If disabled, no Wi-Fi signal can be emitted
2. Changes the password to connect to the Wi-Fi
3. Sets CORIS360®'s time to match the users current local time (according to the time set on the connected computer)
4. Changes the password back to the factory default password ("coris360")

Toolbar Buttons Explained

Open new calibration window to start new calibration.

Stop currently acquiring calibration.

Restart currently acquiring calibration.

Save newly obtained calibration factors to detector.

Open edit detector calibration window to directly edit the energy and FWHM calibration factors on the detector.

Spectrum Buttons Explained

Set cursor mode on spectrum tab. In cursor mode the user can:

- Click and drag right to zoom in
- Click and drag left to reset zoom
- Click on the spectrum to assign spectrum peak to a source energy

Set zoom mode on spectrum tab. In zoom mode, clicking on the spectrum will zoom in on the cursor location.

Reset the zoom of the spectrum to full-scale (mouse scroll when can zoom in/out).

Toggle the spectrum y-axis between logarithmic and linear scale.

6.2. Checking and Re-Calibrating the Detector

The **CORIS360® Detector Calibration** tool has two primary functions: checking that the current detector calibration is correct, and if not, re-calibrating the detector. When checking and re-calibrating the detector, it is advised that the provided calibration puck (containing an exempt ^{152}Eu source) is used.

The following steps detail how to check the detector calibration using the provided ^{152}Eu puck. The ^{152}Eu puck is the recommended source due to its emission of gamma ray peaks over a wide energy range, allowing for an accurate calibration. It should be noted, however, that while the ^{152}Eu puck is the recommended source, any source can be used by following the same steps.

1. Using the supplied M5 hex key, unscrew and remove the circular lid on top of the CORIS360® system.
2. Place the ^{152}Eu puck directly on top of the detector inside the system. The puck should fit snugly around the detector casing.
3. Press the ***Start*** ▶ button in the toolbar menu at the top left of the screen, opening the ***New Calibration*** window.
4. In the ***New Calibration*** window, enter an operator name or use the default name provided.
5. If required, **modify which source or sources the user will use to check the detector calibration** using the ***Add From Library…*** button. The ^{152}Eu source is added by default as this is the recommended source to use.
    a. Whatever sources are contained in the table will be the sources used for the calibration. Therefore, if the user is only using the ^{152}Eu puck, only ***"Eu-152"*** should be present in the table.
6. After all sources have been added, press ***Start*** to begin acquiring the spectrum.
7. If the calibration is good, the automatic radionuclide identification will assign the peaks observed in the spectrum with the energies from the source/s the user added in Step 5.
    a. Once a peak has been identified and assigned with an isotope energy, a blue vertical line is placed on the identified peak location. The corresponding table entry in the ***Energy Calibration*** tab also changes the peak row colour from orange to blue.
    b. Entries in the table of the ***Energy Calibration*** tab remain orange until they have been assigned with a peak in the spectrum, subsequently turning blue.
8. If all peaks from the added source/s are automatically identified, a message box will appear informing the user that the calibration check was successful and will ask if the user wants to stop and save the updated calibration.
    a. If, after 3 minutes, at least 75% of the peaks from the added source/s have been identified, a message box will again appear informing the user that the calibration check was successful and will ask if the user wants to stop and save the updated calibration.
    b. If, after 3 minutes, at least 75% of the peaks have not been identified, the calibration tool will continue running until either 75% of the peaks are identified, or the ***Stop*** ■ button is pressed.
9. If the calibration check is determined to be successful, then the updated calibration should be saved and the detector can continue to be used as normal. If less than 75% of the peaks from the added source/s were identified, the calibration check is determined to be unsuccessful and the detector requires re-calibration.

NOTE. A useful method for confirming if a calibration is good or bad is to check the* Graph all energies *box in the* Energy Calibration *tab which will display on the spectrum the location of all energies currently added to the calibration table.

If the detector requires re-calibration, perform the following steps:

1. If not done previously, complete Steps 1 – 6 above in the method for checking the detector calibration.
2. Since the detector requires re-calibration, it is likely that few or no peaks will be automatically identified. Re-calibration of the detector therefore involves manually assigning peaks in the spectrum to isotope energies from the calibration source being used. The provided ^{152}Eu puck is the recommended source to use.
3. There are two methods to manually assign peaks to isotope energies:
    a. The first method involves using the spectrum directly. Clicking on the spectrum will open a calibration window for the channel number where the cursor was clicked. From this window, the user can assign an energy to the chosen channel number. **The user should therefore click on the centre of any visible peaks and assign them an energy**. This energy can either be entered manually or can be selected from the list of peaks the user previously added. Once an energy has been chosen, press ***Apply*** to assign the energy to the channel number.
    b. The second method involves using the table in the ***Energy Calibration*** tab. Double-clicking in the ***Channel*** column of the table allows the user to manually enter the channel number for the corresponding energy. See Section 6.3 for a detailed explanation of the ***Energy Calibration*** tab.
4. **A minimum of four peaks need to be assigned an energy before the calibration fit is deemed accurate**. However, the more peaks that are assigned an energy, the more accurate the calibration.
    a. The ***Calibration Fit*** tab provides information on the fit parameters and quality of the fit. The calibration curve should fit the data points well, and deviation from this likely indicates that the user has assigned the wrong energy to the peak. See Section 6.3 for a detailed explanation of the ***Calibration Fit*** tab.

NOTE. Determining which peak is associated with which energy can be difficult when the calibration is wrong. A useful tool when assigning the peaks of the ^{152}Eu source is to look at the labelled ^{152}Eu gamma spectrum provided in Appendix D.

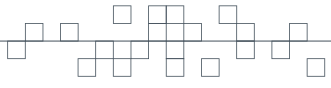
5. Once the user has assigned enough peaks and is satisfied with the new calibration, save the new detector calibration parameters using the ***Apply*** button in the toolbar menu at the top of the window.
6. Once saved, confirm the new calibration is accurate by pressing the ***Start*** button again and acquiring a new spectrum. Any added sources should now be automatically identified. If they are not, start again at Step 1 and repeat the re-calibration procedure.

NOTE. If the individual energy and FWHM calibration parameters are already known, the detector can be re-calibrated without having to follow the steps above. To apply these parameters directly, click the **Edit** button in the toolbar menu and enter the corresponding values (see Section 6.1).

6.3. Using the Energy Calibration and Calibration Fit Tabs

The **CORIS360® Detector Calibrator** tool provides multiple methods for viewing, editing, and analysing a detector's calibration. Two of these methods involve using the ***Energy Calibration*** and ***Calibration Fit*** tabs. The primary uses of the ***Energy Calibration*** tab are to add nuclides that the user is using to check and re-calibrate the detector, and to assign channel numbers to the energies of these nuclides. The ***Info*** ⓘ button displays the energies of the main peaks for the selected source. Custom entries into the calibrator table can also be added for scenarios where a source is not present in the drop-down list. The entries in the calibration table are coloured either blue or orange, representing whether the energy has been assigned a channel number or not, respectively. The tab also provides the user with the ability to plot all of the energies currently in the calibration table onto the spectrum above using the ***Graph All Energies*** check box. This is a very useful tool when checking and re-calibrating a detector.

The primary use of the ***Calibration Fit*** tab is to determine the quality of a calibration. In an ideal setup, a calibration fit would be perfectly linear, however this is not achievable with scintillator based detectors. Therefore, the aim of the calibration curve is to fit the data points as closely as possible. Information on the calibration fit will not be displayed until at least four energies have been assigned a channel number. Once a minimum of four calibration points have been added, the tab will provide the user with the calibration fit parameters and quality of the fit. This information will be coloured either blue or orange, indicating whether the fit is good or bad, respectively. The more energies that are assigned a channel number, the more accurate the calibration will be. The ***Copy Fit Parameters to Clipboard*** button copies the calibration curve fit parameters (a, b, c) so that they can be easily stored, viewed and saved elsewhere.



6.4. Exporting Data

Once a spectrum has been acquired for checking or re-calibrating a detector, the ***CORIS360® Detector Calibrator*** tool provides the ability to export the spectrum into a zip file for record keeping and external analysis. A description of each file contained in the exported zip file is given below:

Export Information .txt file	A text file containing all of the essential calibration session information such as the detector name, original and new detector calibration parameters and the nuclides used in the calibration.
Export Spectrum .csv file	A csv file containing the counts in each energy bin of the spectrum. The first column in the file is the energy (in keV) and the second column is the number of counts at that energy.
Export Spectrum .n42 file	A n42 file containing the same information as the csv file of the same name, however the data is in a format that can be readily accessed in spectroscopy analysis software.

To export the spectrum, click ***File > Export Spectrum*** from the menu bar in the top left of the window and follow the prompts to save the spectrum in the desired location.

7. SPECIFICATIONS

Dimensions	210 mm × 425 mm (D × H) | 8.3” × 16.8” (D × H)
Weight	15 kg | 33 lbs
Power Supply	100 VAC – 240 VAC (47 Hz – 63 Hz) Input Provides 24 VDC and minimum 90 W to CORIS360®
Operating Temperature	5 °C – 40 °C (Ambient) | 41 °F – 104 °F (Ambient)
Storage Temperature	5 °C – 40 °C (Ambient) | 41 °F – 104 °F (Ambient)
Indoor or Outdoor Use	Indoor and outdoor (IP54 rated)
Humidity Range	Max 70% relative humidity, non-condensing
Altitude Range	Max 3000 m
Overvoltage Category	OVC II
Pollution Degree	Pollution degree II
Detector Type/s	Cylindrical Ø1.5” CLLBC Scintillator with SiPM array (CLLBC15, Red) Cubic 0.5” CLLBC Scintillator with SiPM array (CLLBC05, Blue)
Energy Resolution	~ 4% FWHM @ 662 keV
Energy Range	40 keV to >3 MeV Gamma and Thermal Neutron Detection
Imaging Region of Interest	Peaks and non–peaks
Gamma Field of View	360° × 90° (H × V)
Optical Field of View	360° × 90° (H × V)
Max. Angular Resolution	20° ± 1° (CLLBC15 detector) 15° ± 1° (CLLBC05 detector)
Dose Rate Range	0.5 µSv/h – 2 mSv/h (CLLBC15 detector) 1 µSv/h – 40 mSv/h (CLLBC05 detector)
Radionuclide Identification	Customisable library of radioisotopes included
Start-Up Time	< 1 minute
Communication	Ethernet or Wi-Fi

8. TROUBLESHOOTING

8.1. General

If any unusual error occurs in CORIS360® or the software, performing a full power cycle of the device and restarting the software will solve the issue in most cases. To perform this, complete the following steps:

1. Close the software and power off CORIS360® by holding down the power button for 3 seconds.
2. After a few seconds, turn CORIS360® back on and open the software.
3. Check the ***CORIS360 Status*** in the bottom right corner of the software window and confirm that it reads ***"Connected"***.

If the error persists following the troubleshooting steps above, please contact the customer support team at *support@coris360.com*.

8.2. CORIS360® Is Not Connecting To The Computer

If CORIS360® cannot connect to the computer, indicated by the ***CORIS360 Status*** in the bottom right corner of the software window displaying ***"Disconnected"***, some network settings may need to be configured. The cause of a connection issue can depend on the CORIS360® firmware version. To determine the firmware version of your CORIS360® device, click on the ***CORIS360 Status***, opening the ***CORIS360 Information*** window.

<u>For CORIS360® devices with firmware versions below 1.0.6</u>

Connection issues will arise when the static IP address to communicate with CORIS360® has not been setup correctly. A static IP address will need to be setup for every new computer that connects to CORIS360®, however it will only be required the first time a new computer connects to the device. See Appendix A for detailed steps on how to correctly setup the static IP address.

These firmware version do not have a Wi-Fi capability.

<u>For CORIS360® devices with firmware 1.0.6 and above</u>

The CORIS360® device will automatically assign the IP address to the connected computer. Therefore, no static IP addresses should be assigned for either the ethernet or Wi-Fi connectivity.

If using Wi-Fi, ensure that the computer has been connected to CORIS360® using the Network icon  in the Windows taskbar. The name of the network for your CORIS360® device is "CORIS360_<SERIAL NUMBER>". For example, a device with serial number "001C10" will have a network name "CORIS360_001C10". The serial number of your device can be found on the bottom of your CORIS360®. The default Wi-Fi password for your CORIS360® device is "coris360".

If the error persists and the computer can still not connect to CORIS360®, please contact the customer support team at *support@coris360.com*.

8.3. Spectrum Energy Calibration Appears Wrong

If a spectrum is producing a peak at an energy that is known to be incorrect, it is likely that the detector needs to be re-calibrated. See Section 6 for instructions on how to perform the re-calibration.

8.4. Location of Radiation in Gamma Image Does Not Make Sense

A gamma image created from bad data will produce inaccurate and unstable results. Therefore, conclusions should not be drawn from images created from bad data. The ***Image Quality*** column in the ROI table provides information on the quality of gamma images and therefore their data. It is recommended that no conclusions or interpretations of results are made until the gamma image for a ROI achieves an image quality of at least ***"Good"***.

Some causes for bad data and therefore poor image quality include:

- Too few counts per sample or too few samples in total (see Section 5.1 for further information)
- Selecting a bad custom ROI (see Section 5.2 for further information)
- Radiation is present outside the 360° × 90° field of view. This may require more samples and/or longer sample times for the image capture to produce a good quality image.

Avoiding the causes listed above will result in better quality data and therefore better quality gamma images.

If, after avoiding the above causes, it is still believed that the location of the radiation does not make sense, test the performance of CORIS360® using a strong source at a known location. If the radiation is again not present at the known location in the gamma image, please contact the customer support team at *support@coris360.com*.

8.5. Automatic Radionuclide ID is Not Identifying Peaks

If well-defined peaks are visible in the spectrum but the automatic radionuclide identification is not identifying them, a few scenarios could be occurring.

Firstly, the peak may not be identified because the detector has gone out of calibration. To recalibrate the detector, see Section 6.

Another reason why the peak may not be identified is that the radioisotope belonging to the peak may not be included in the software's radionuclide library. The radionuclide library is fully customisable, with the default library containing 15 common radioisotopes that majority of the users will need. If a user requires additional radioisotopes to be included within the library, see Section 4.8 for steps on how to customise the library.

Lastly, and least likely, the issue could be due to a reduction in the resolution of the detector due to damage to the detector. A reduction in resolution will cause peaks in the spectrum to become wider than normal, increasing their full widths at half maximum (FWHM). As stated in Section 7, the provided detectors should have an energy resolution of ~4% FWHM at 662 keV peak (^{137}Cs). If the detector resolution has degraded, or if assistance is required for calculating the energy resolution, please contact the customer support team at *support@coris360.com*.

9. CONTACT/SUPPORT INFORMATION

For any assistance regarding the device, its accessories, the software or general questions, please contact the customer support team at *support@coris360.com*.

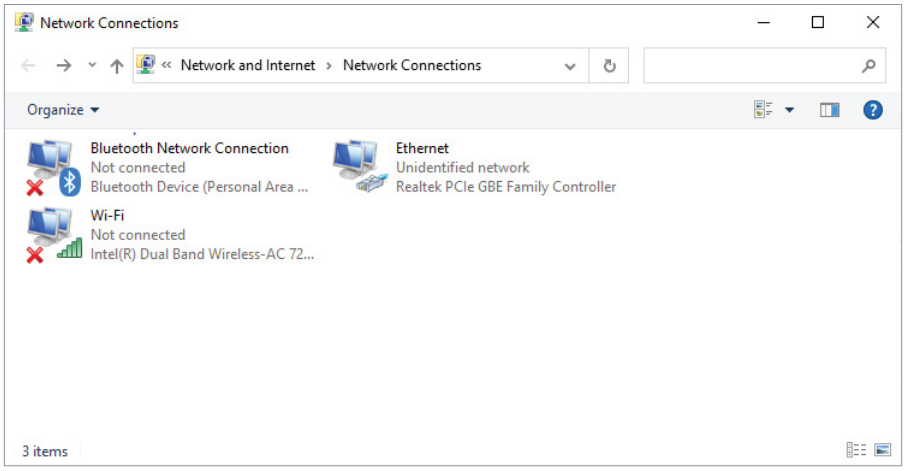
Any unauthorised servicing, maintenance or modifications to the device is not permitted. For assistance with any of these matters, please contact the customer support team at *support@coris360.com*. Only qualified personnel from the CORIS360® customer support team can perform any servicing, maintenance or modification.

APPENDIX A. SETTING UP ETHERNET PORT ON COMPUTER

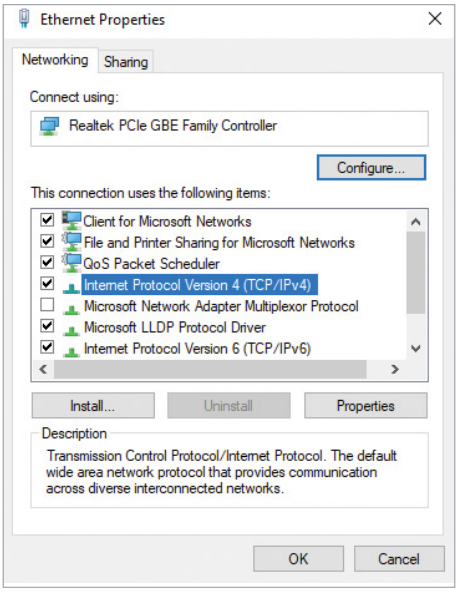
For CORIS360® devices with firmware versions 1.0.6 and above, the system will automatically assign IP addresses and therefore automatically connect to the computer being used. For CORIS360® devices with firmware versions below 1.0.6 however, the Ethernet port on the computer will need to be set up by assigning a static IP address (IP Address: 192.168.0.1 Subnet Mask: 255.255.255.0) whenever the user is connecting CORIS360® to a computer for the first time. Assigning a static IP address is simple and is required to ensure that the computer can always communicate with CORIS360®. Admin rights on the computer are required when setting up an ethernet port.

To set up the computers Ethernet port by assigning a static IP address, follow the steps below:

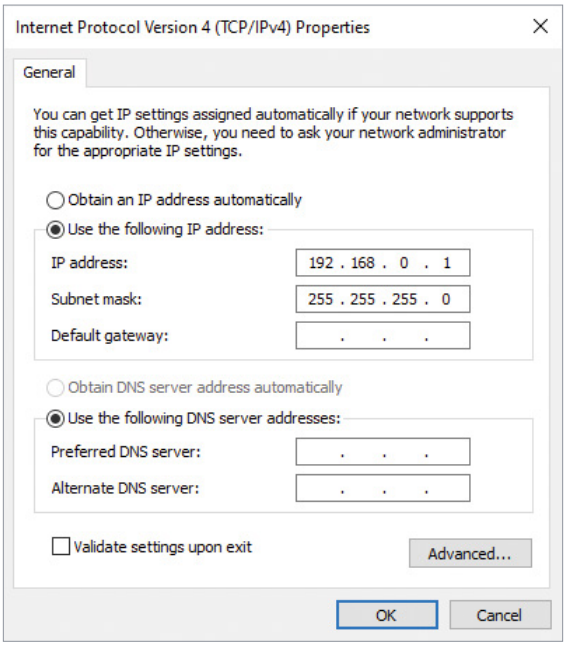
1. Navigate to *Network Connections* on the computer by either searching *"network connections"* from the start menu search bar or by navigating to *Control Panel* > *Network and Internet* > *Network and Sharing Centre* and then selecting *Change adapter settings* from the menu on the left of the window. The *Network Connections* window should look similar to the image below.



2. From here, right-click on the Ethernet connection and select *Properties*, opening the window shown below.



3. Select *Internet Protocol Version 4 (TCP/IPv4)* from the list and click the *Properties* button, opening the window shown below.



4. Enter the values shown above into the properties window. Specifically, click the *Use the following IP address* radio button, then in the *IP address* field enter *192.168.0.1* and in the *Subnet mask* field enter *255.255.255.0*.
5. Lastly, click the *OK* button then close the remaining windows (all windows must be closed before the static IP address will assign correctly). The static IP address has now been assigned and the Ethernet port is now set up and ready to connect to CORIS360®.

APPENDIX B. IMAGE QUALITY METRIC EXPLAINED

Section 5.1 describes the output from the image quality metric and how to interpret its results. This appendix provides some information on how the image quality metric works and how the output is calculated. As an overview, the metric works by analysing the complexity of the current imaging scenario, then compares this with a lookup table that has utilised millions of simulations to describe the relationship between the image complexity and measured counts. This analytical comparison, accompanied with monitoring of the convergence of the gamma image, provides a method for calculating the confidence in the current gamma image quality. The simulated data takes into account the size and type of detector being used in the system, the energy range of the ROI being reconstructed over, and the intensity of the source/s being imaged.

APPENDIX C. EXAMPLE REPORT

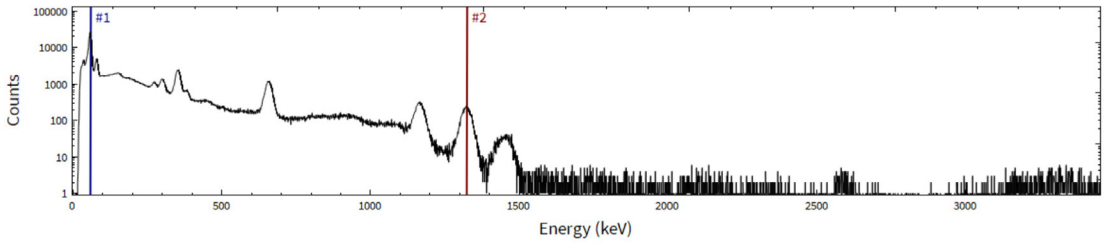
Radiation Imaging Report

Image Capture Information

Name:	Multiple Sources Example	Date:	Wed Jun 09 2021
System:	CORIS360 (S/N: 000C10)	Detector:	CLLBC 1.5 Inch (S/N: AA000)
Location:	ANSTO	Operator:	User
Description:	Imaging multiple sources		

Start time:	12:59:48	End time:	13:58:54	Elapsed time:	00h 59m 06s
Samples:	161	Sample Length (s):	20		
Identified ROIs (ID):	2	Other ROIs (User):	0		

Energy Spectrum



Regions of Interest

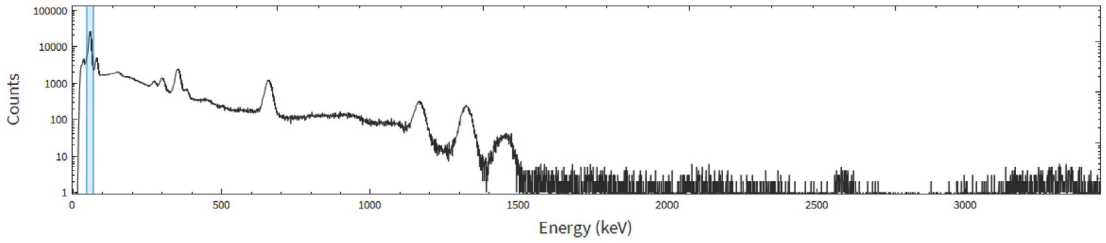
	Type	Name	Energy (keV)	Range (keV)	Counts	Rate (cps)	Quality	Page
#1	ID	Am-241	59.5	47.4 - 67.9	344669	106.9	Excellent	2
#2	ID	Co-60	1332.49	1289.7 - 1358.0	10501	3.3	Excellent	3

Radiation Imaging Report

CORIS360

Region of Interest Information

Name:	Am-241	Type:	ID	Energy (keV):	59.5
Range (keV):	47.4 - 67.9	Counts:	344669	Rate (cps):	106.9



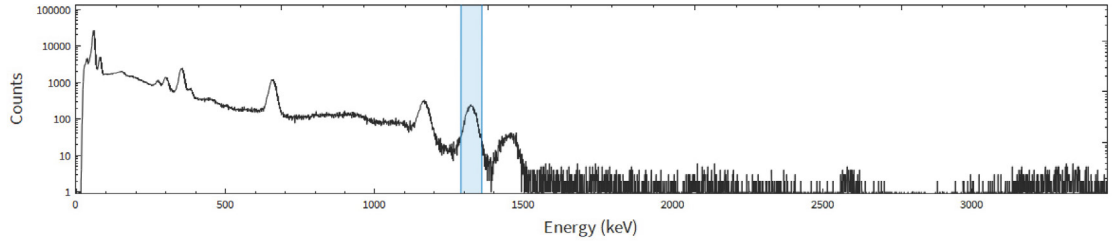
Radiation Image Overlay

Image Quality: **Excellent**

Radiation Imaging Report

Region of Interest Information

Name:	Co-60	Type:	ID	Energy (keV):	1332.49
Range (keV):	1289.7 - 1358.0	Counts:	10501	Rate (cps):	3.3



Radiation Image Overlay

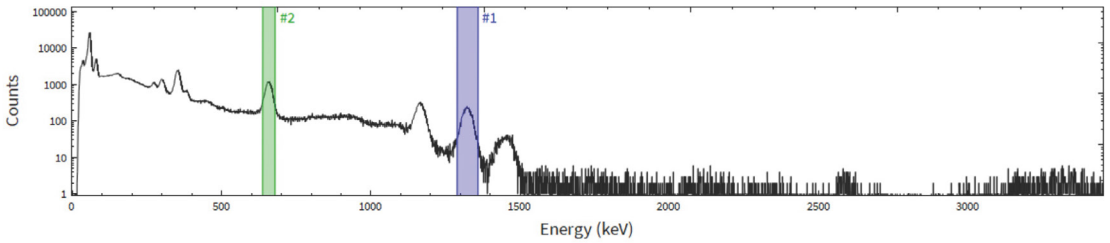
Image Quality: **Excellent**

Radiation Imaging Report

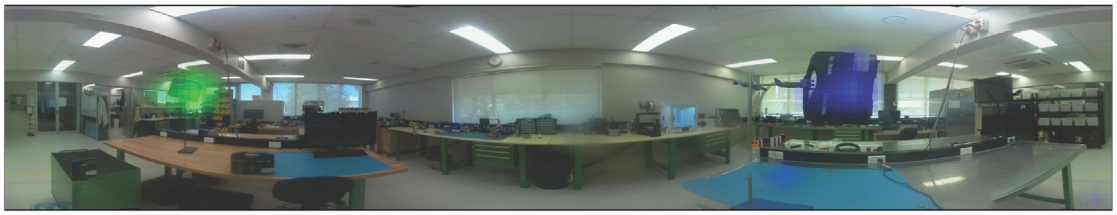
CORIS360

Combined Region of Interest Information

	Type	Name	Energy (keV)	Range (keV)	Counts	Rate (cps)	Quality
#1	ID	Co-60	1332.49	1289.7 - 1358.0	10501	3.3	Excellent
#2	ID	Cs-137	661.66	636.8 - 680.5	39557	12.3	Excellent



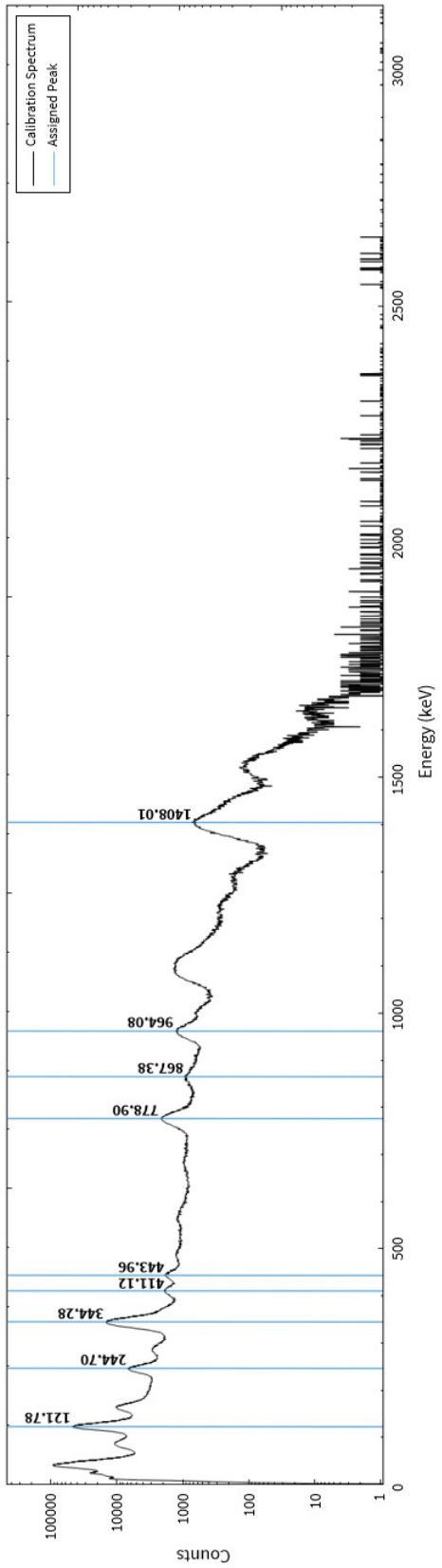
Radiation Image Overlay



Legal Information

By using the CORIS360® radiation imaging system, including ANSTO's proprietary CORIS360® Radiation Imaging software (Software), you agree to be bound by the content of this disclaimer, the Terms and Conditions – Sale of CORIS360®, as well as any terms accepted when you first accessed the Software. ANSTO does not guarantee or warrant that any tangible or intangible material produced or output generated through your use of the CORIS360® will be suitable or fit for any particular purpose of the uses to which you may put any such material produced or output generated through your use of the CORIS360® and to the maximum extent permitted by law ANSTO accepts no liability for the manner in which the CORIS360® may operate, results that can be received from the CORIS360®, except to the extent of any express written warranty provided under the Terms and Conditions – Sale of CORIS360®. Your use of the CORIS360® is at your own risk. You must evaluate, and bear all risks associated with, the use of any tangible or intangible material produced or output generated through your use of the CORIS360® including reliance on the accuracy, completeness, suitability for any purpose or usefulness of any such material produced or output generated through your use of the CORIS360®.

APPENDIX D. ^{152}Eu GAMMA SPECTRUM



CORIS360®

Contact us

For further information on CORIS360® including case studies and technical reports please visit:

Website
www.coris360.com

Email
support@coris360.com

Phone
+61 2 9717 3311

Australian Government | ANSTO

CORIS360® is a product of ANSTO, the Australian Nuclear Science and Technology Organisation, with over 60 years of experience in meeting the nuclear needs of industry.