

Analysis of X-ray Computed Tomography calibration spheres using the Avizo Software Metrology workroom

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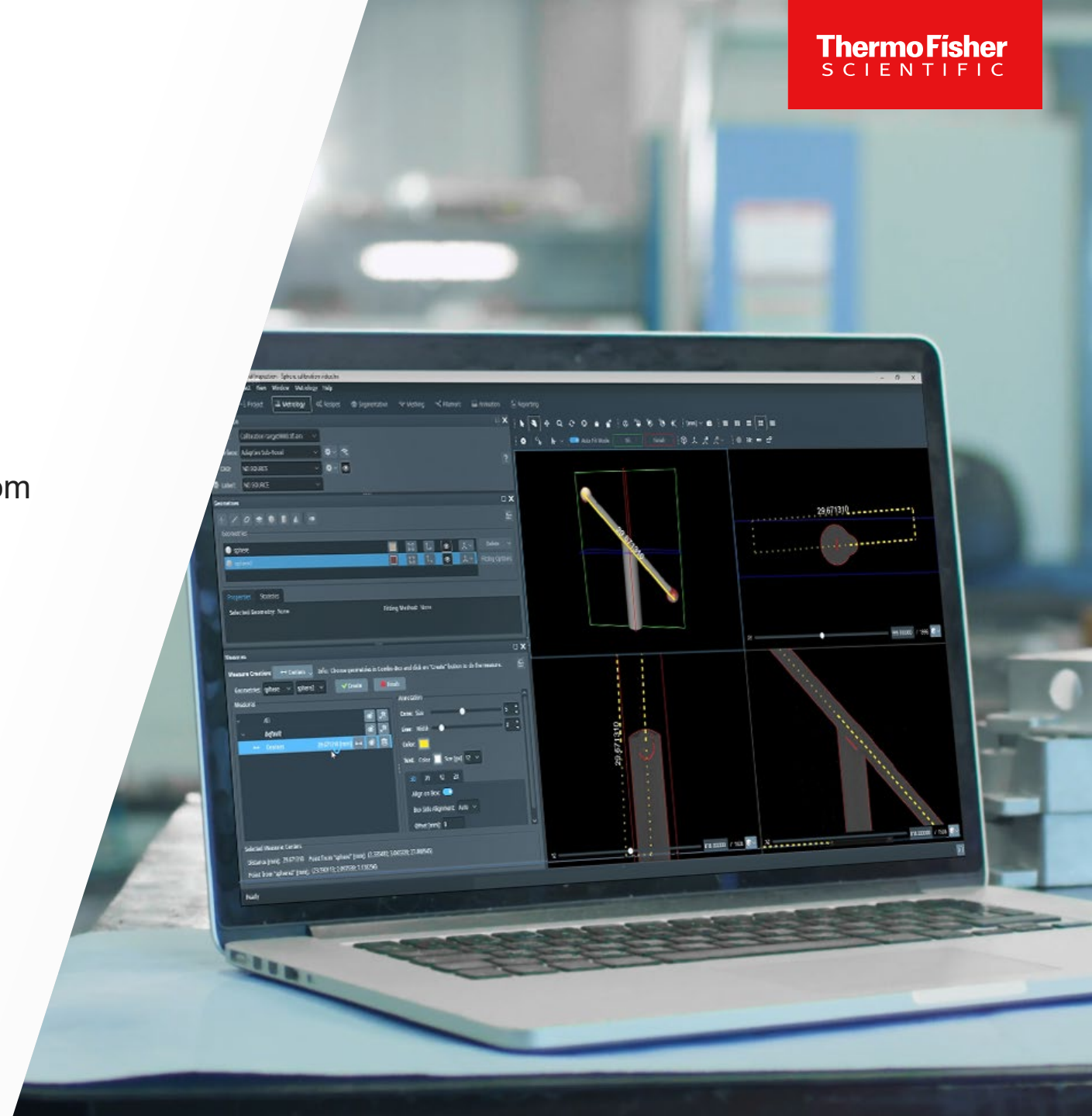
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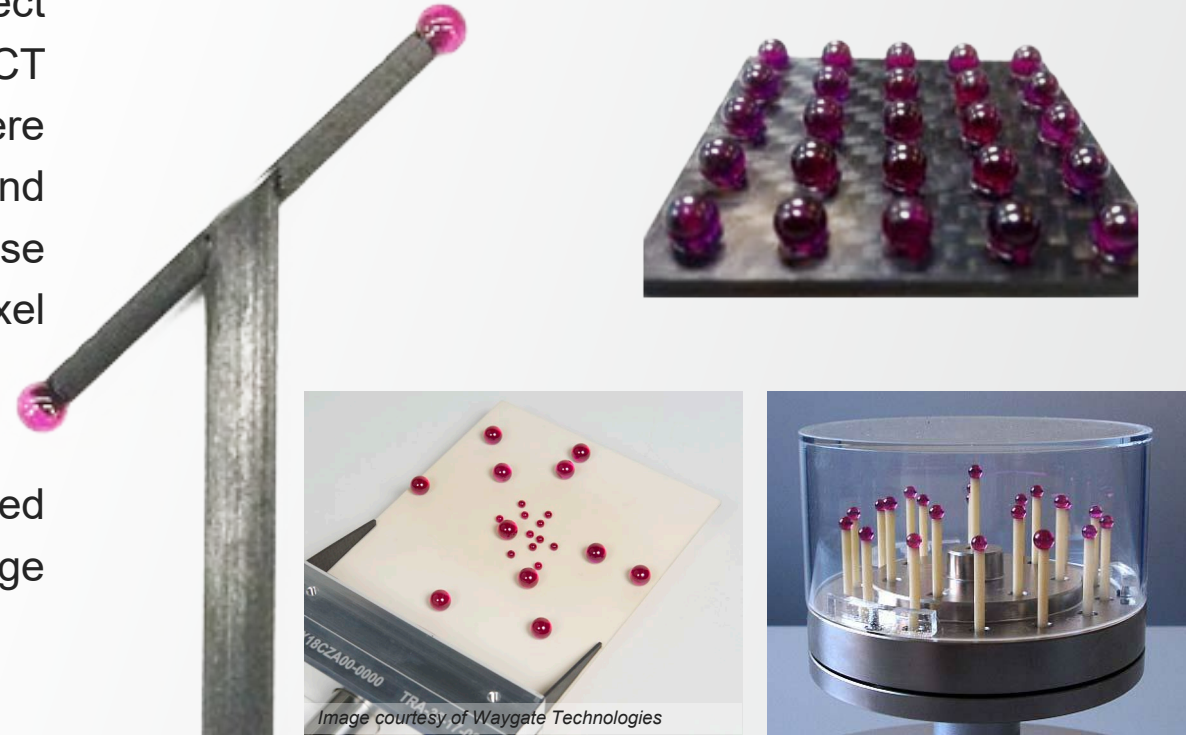


Types of calibration targets used for X-ray CT voxel size calibration

The effective voxel size for an X-ray CT data set will have a direct effect upon measurement accuracy. A number of X-ray CT companies produce metrology grade X-ray CT instruments where the effective voxel size is both defined to a tighter tolerance and higher repeatability than the standard systems. These systems use a variety of voxel calibration targets for defining the effective voxel size over a range of magnifications.

For a standard X-ray CT instrument a calibration target can be used to refine the voxel size for a scan position (assuming the stage position has not been moved).

The present exercise demonstrates how to extract the sphere to sphere centre distance of a calibration target in Thermo Scientific™ Avizo™ Software in order to refine the voxel size.



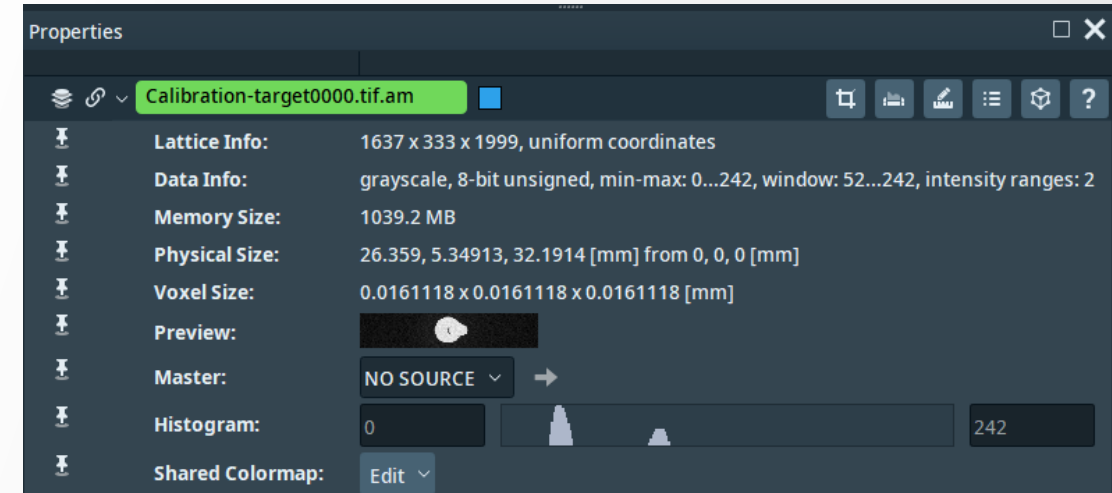
Some examples of typical X-ray CT calibration targets

Data preparation

Voxel size definition

The calibration target data can be loaded in using any of the standard method. It is essential when the data is loaded that either the voxel size from the reconstructed file is used or a value of one. Both methods have advantages:

- Using the reconstructed voxel size associated with the magnification is essential if the reader is performing a number of measurements over a range of magnifications in order to define the correct instrument FDD for calibration over the whole instrument magnification range.
- Using a voxel value of one allows the user to produce a quick voxel calibration for the scan magnification. In this case the true voxel size (recalibrated) is simply the calibrated sphere distance divided by the number of voxels from the sphere centre to centre. This method is not used in the following example.



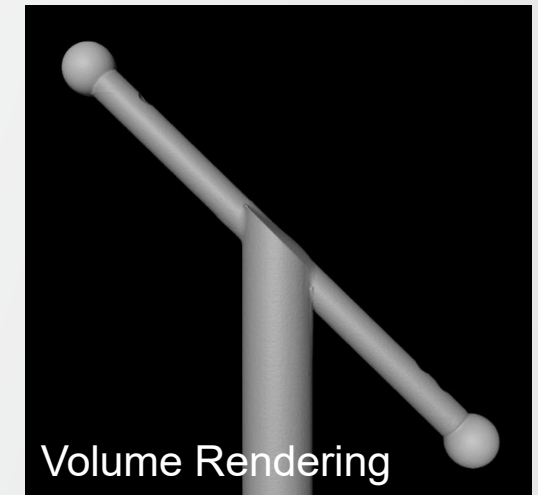
Data preparation

Checking the data

When the data is loaded into Avizo Software, check that the calibrated spheres show a good contrast to the background (using the Ortho Slice display).

Next, ensure that the surfaces of the sphere show a smooth surface that is free of artefacts, this can be done quickly using a Volume Rendering.

Any adverse metal particles will directly affect the surface profile while impact damage to the spheres will render them useless for voxel calibration measurements!



Introduction to Avizo Software Metrology workroom

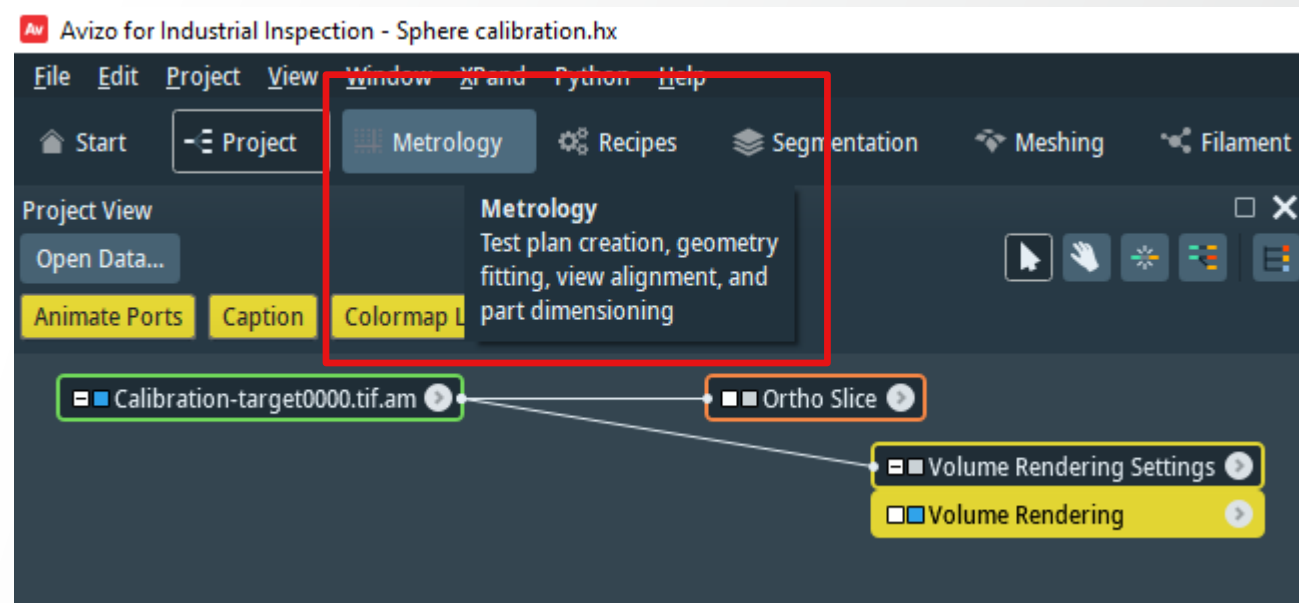
Opening the Metrology workroom

The Metrology workroom is only available in Avizo Software for Industrial Inspection, the Avizo application dedicated to industrial inspection, quality control and materials characterization.

The Metrology workroom is located next to the Project workroom in the workrooms' toolbar.

Note that prior to moving to the Metrology workroom, the data does not require any segmentation.

More information about the Metrology workroom can be found in the dedicated "Avizo Xmetrology Extension" section of Avizo Software documentation and in our video tutorials.



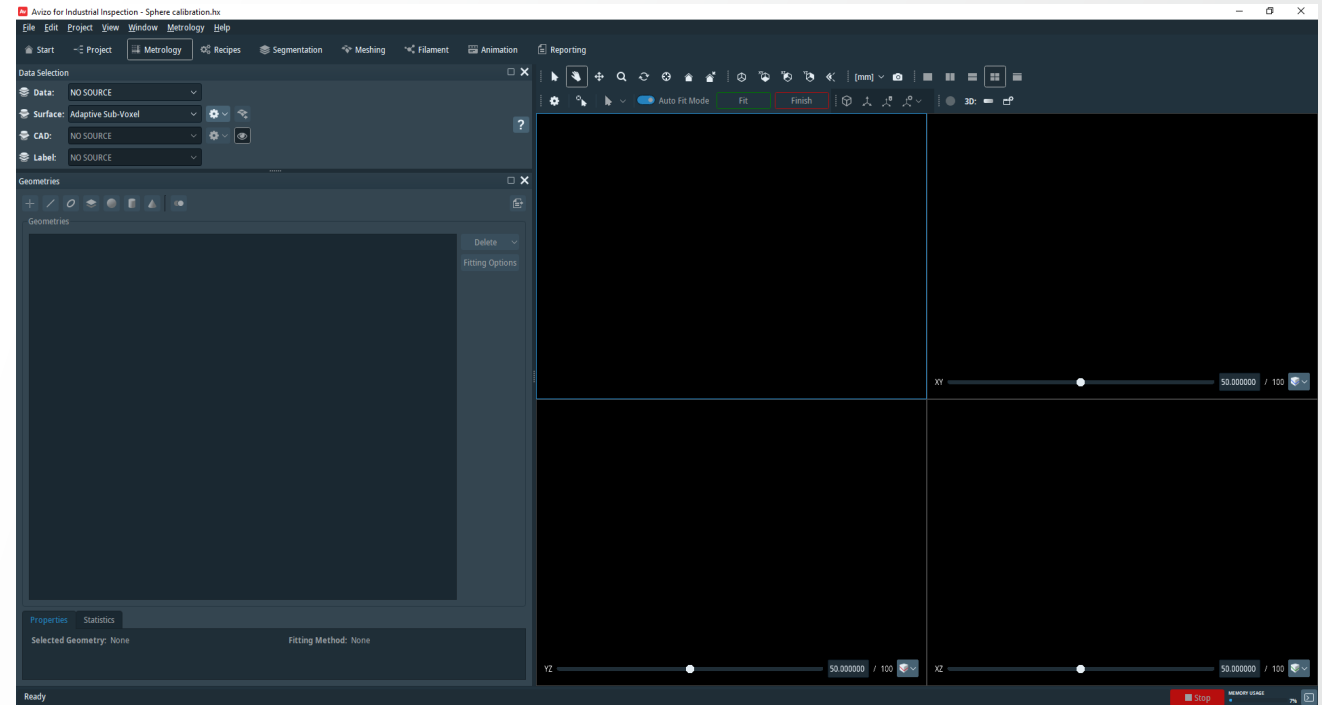
Introduction to Avizo Software Metrology workroom

The Metrology workroom user interface

The layout of the Metrology workroom is reminiscent of the Project and Segmentation workrooms with the control tools on the left-hand side and the viewing windows on the right-hand side.

The Data Selection panel allows the user to input the required volumes as well as CAD and label surfaces and also to perform the surface determination from the selected data.

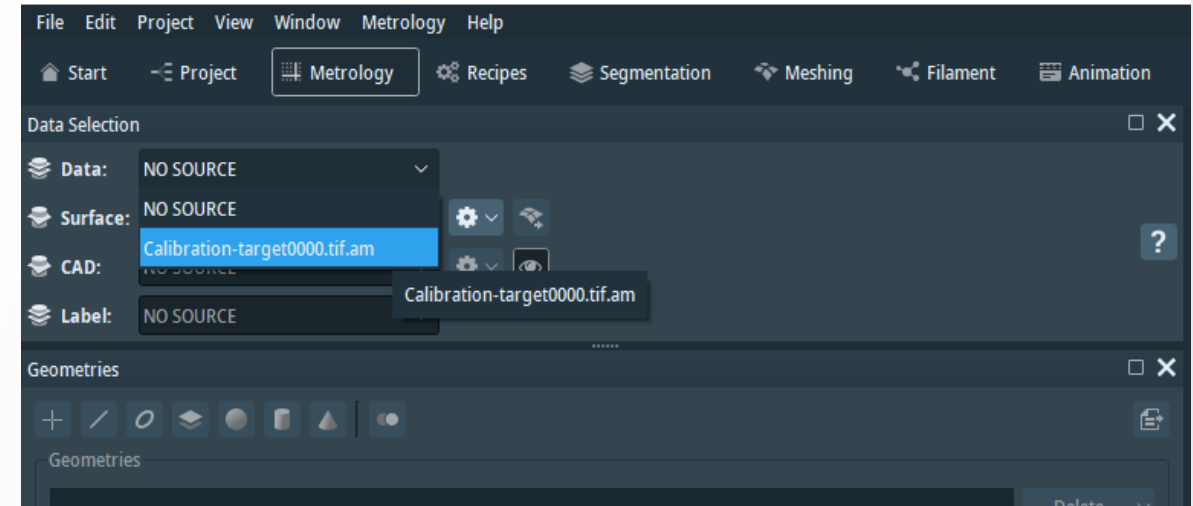
The Geometries panel is used specifically for the fitting of surfaces to the component. This example will focus on the use of the sphere fitting tool.



Surface determination

Selecting the data

To select data for processing click on the Data tab and a dropdown menu will appear. The dropdown menu will list all data volumes previously created in the Project View. In this example we select the calibration target data.



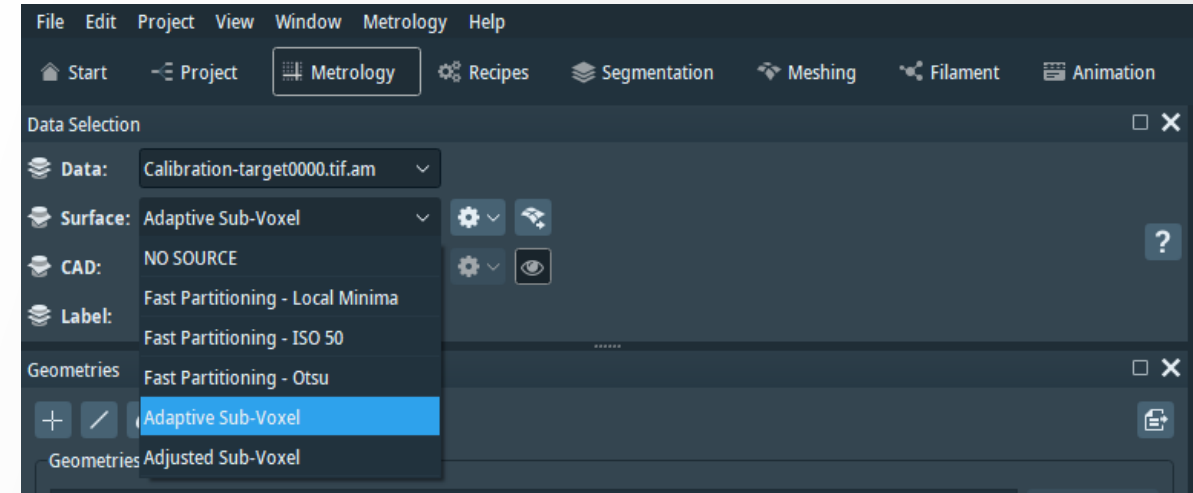
Surface determination

Generating the component surface

Once the data is selected, a surface must be extracted. The Metrology workroom contains a number of surface determination methods based upon the voxel grey scale range. Further information regarding these methods can be found in the workroom documentation.

The correct surface determination method for the data will be the one that most closely matches the surface of the data. It is recommended that the user tries each method on his data and checks the surface matching using the viewing windows.

In this example the Adaptive Sub-Voxel method was selected since it produces a closer match to the curved surfaces of the spheres.



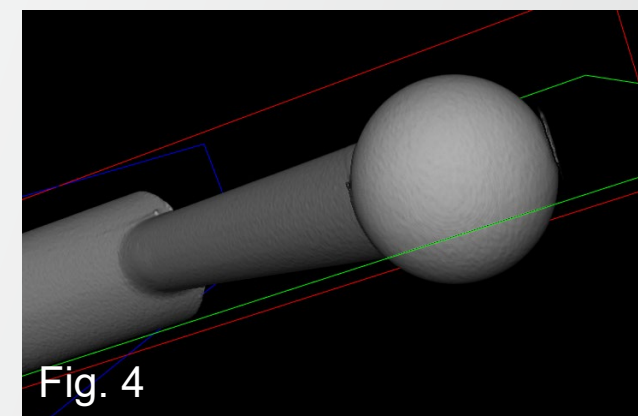
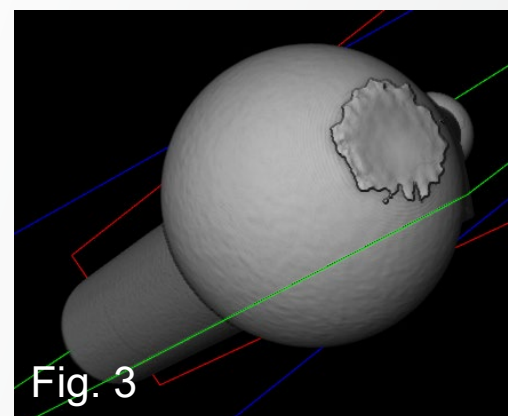
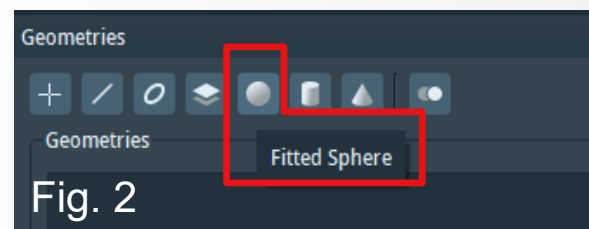
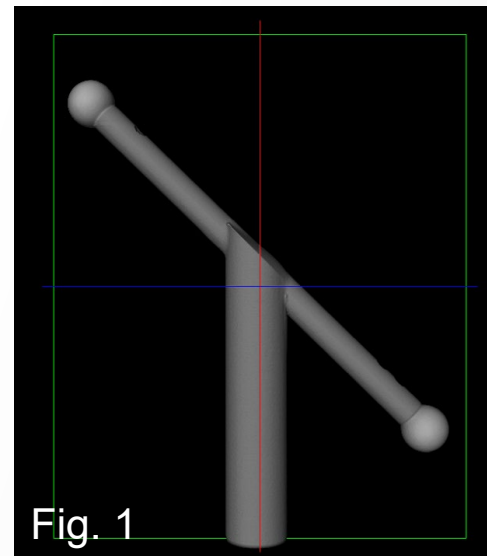
Fitting a sphere surface

Preparing for sphere fitting

Once the surface has been generated the sphere fitting of the ruby spheres can be started. Surface fitting for a number of shapes can be found in the Geometries panel.

Geometry fitting relies on selecting points on the surface. As we will select the points by clicking in the 3D viewer, it is important to orientate the desired sphere to avoid any artefacts, and that before selecting the sphere fitting tab (Figure 2). Figure 3 shows where the reconstructed sphere surface has been distorted, this could be a defect on the surface or an artefact from the reconstruction process, if selected, this region will distort the sphere fitting therefore giving a false value.

We identify a clean surface on sphere (Figure 4) and then select the sphere fitting tab.



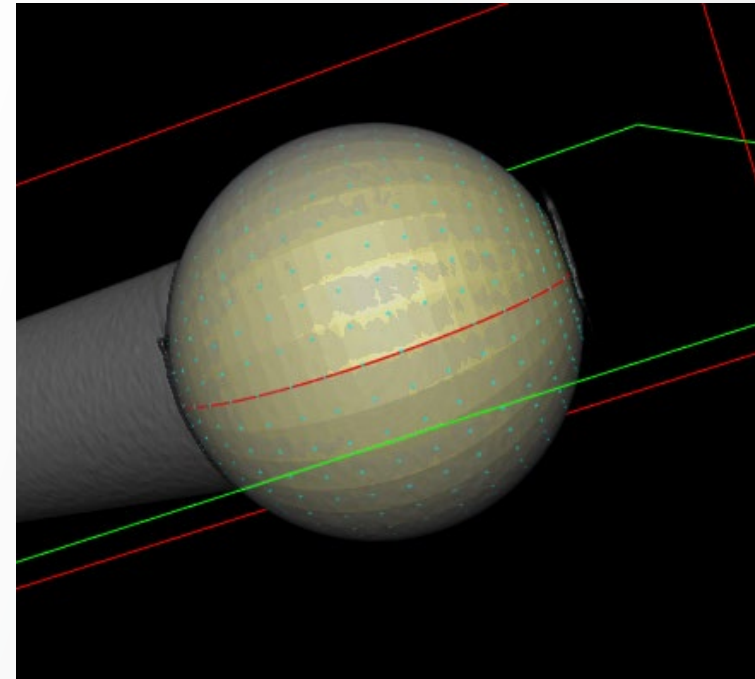
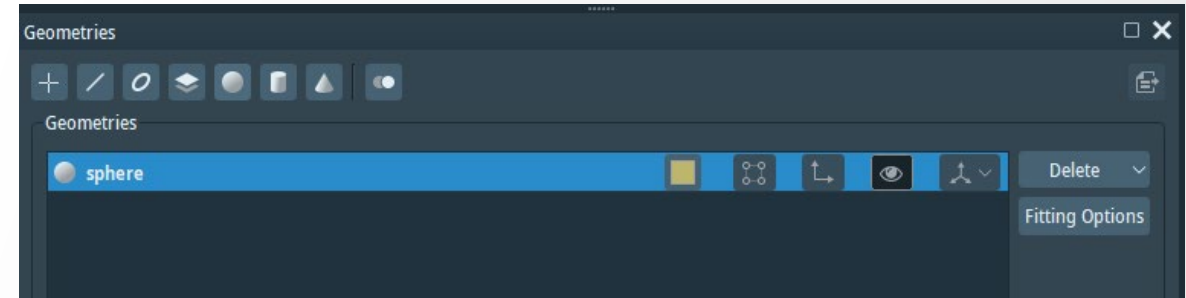
Fitting a sphere surface

Sphere fitting

When the sphere fitting tab is selected a sphere profile will be generated in the Geometries panel. Information about fitting tools and methods can be found in the workroom documentation.

Move the cursor across the 3D viewing window and click on a number of points on the sphere surface. When selecting points, try to uniformly spread the points across the sphere surface. Once the points are selected a sphere surface is automatically generated based upon the locations that were selected. If the generated sphere surface is a good fit, press the Finish button in the geometry fitting toolbar (on top of the viewers).

Next re-orientate the calibration target to select the second sphere and then select the sphere fitting tab to create a second profile.



Measuring the sphere to sphere centre distance

Introduction

Figure 1 shows an example where the sphere fitting has been applied to the two ruby spheres on a calibration target. The fitted spheres are labelled as sphere and sphere2 in the Geometries panel and are visually represented by gold and green in the 3D viewing window.

Information regarding the sphere centre coordinates and radius can be obtained by selecting either profile (Figure 2). Although the sphere radius is calculated, this should not be used for X-ray CT voxel calibration. This is because the very nature of X-ray CT will result in a very small erosion of the surface geometry in the 3D volume. Therefore a voxel calibration is based upon the sphere centre to centre distance. This also has the advantage of covering a larger distance resulting in a better refinement.

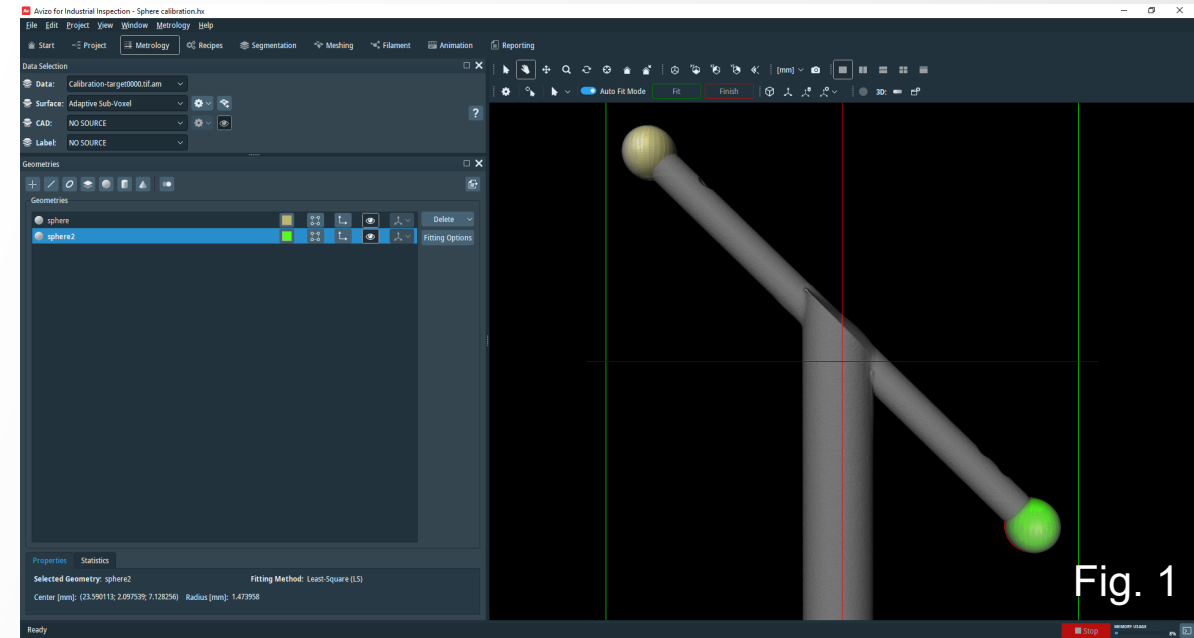


Fig. 1

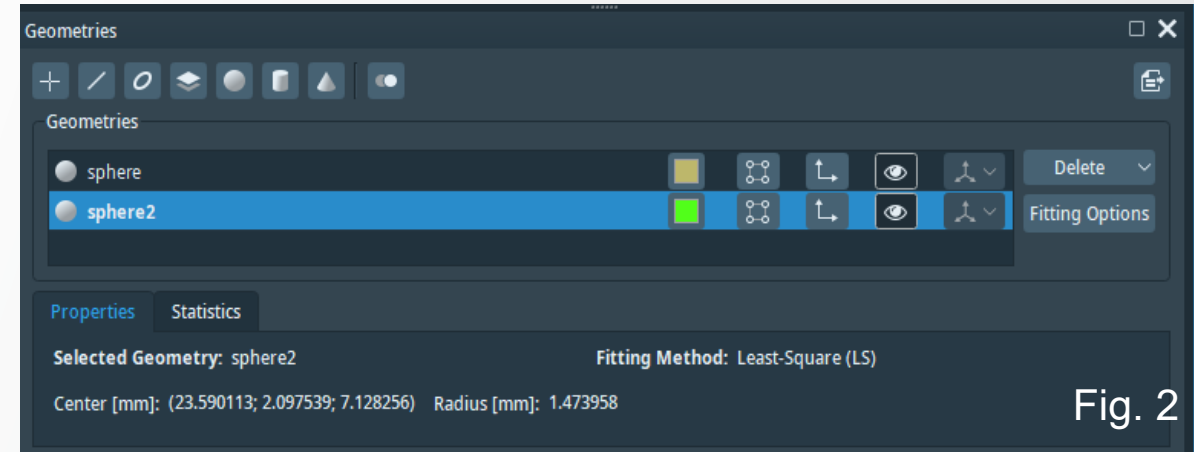


Fig. 2

Measuring the sphere to sphere centre distance

The Measures panel

To measure the distance from the centre of sphere 1 to the centre of sphere 2 select the Measures panel that gives access to all the measurement tools.

The Measures panel can be found by right clicking on the Metrology tab (Figure 1) and then selecting Measures which is located near the bottom of the menu. A new panel will appear.

The measures panel has three parts:

- Measure Creation for creating the specified measures
- Measures pane which is a record of the measures created
- Annotation pane that is used for annotating the 2D and 3D images

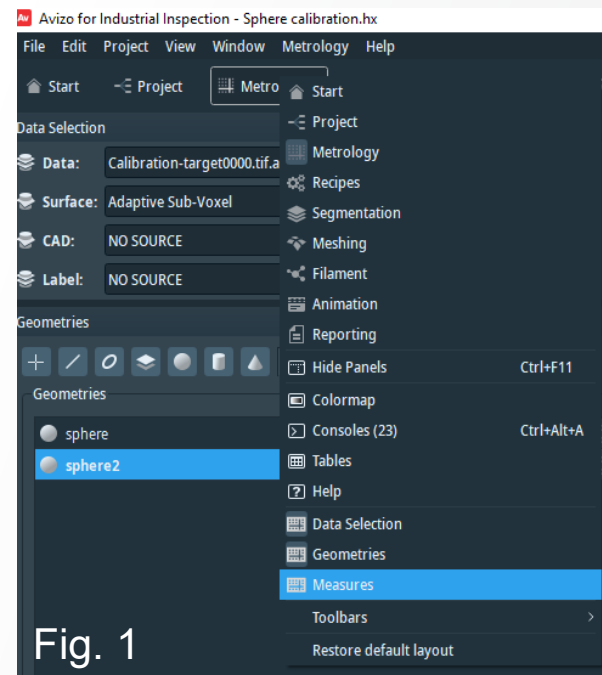


Fig. 1

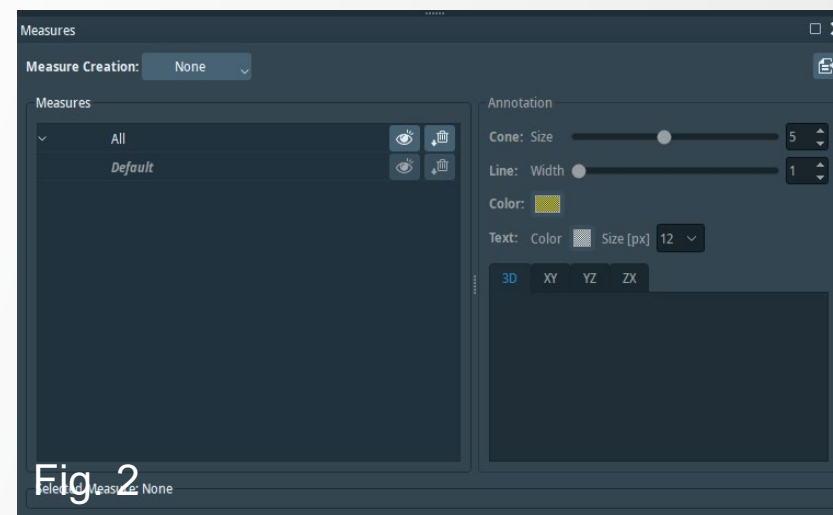


Fig. 2

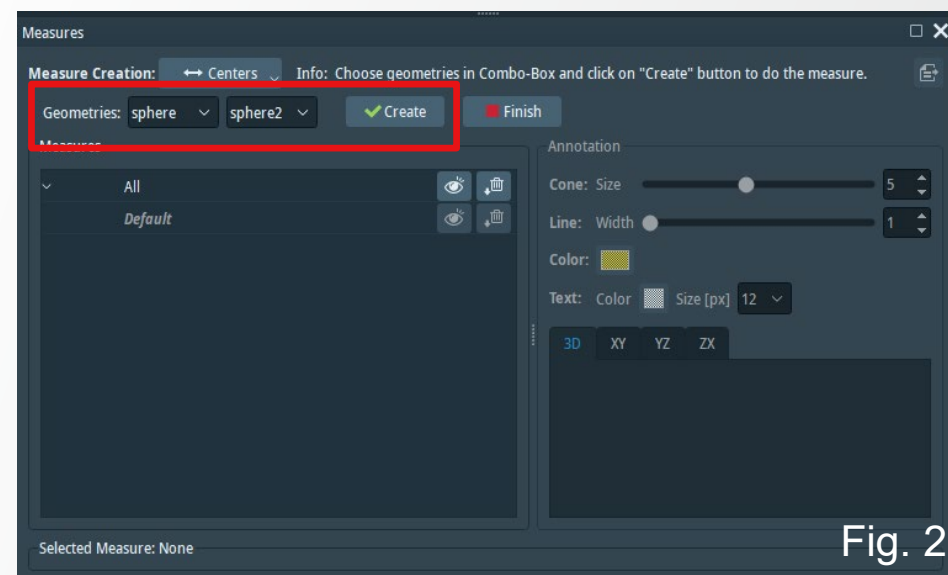
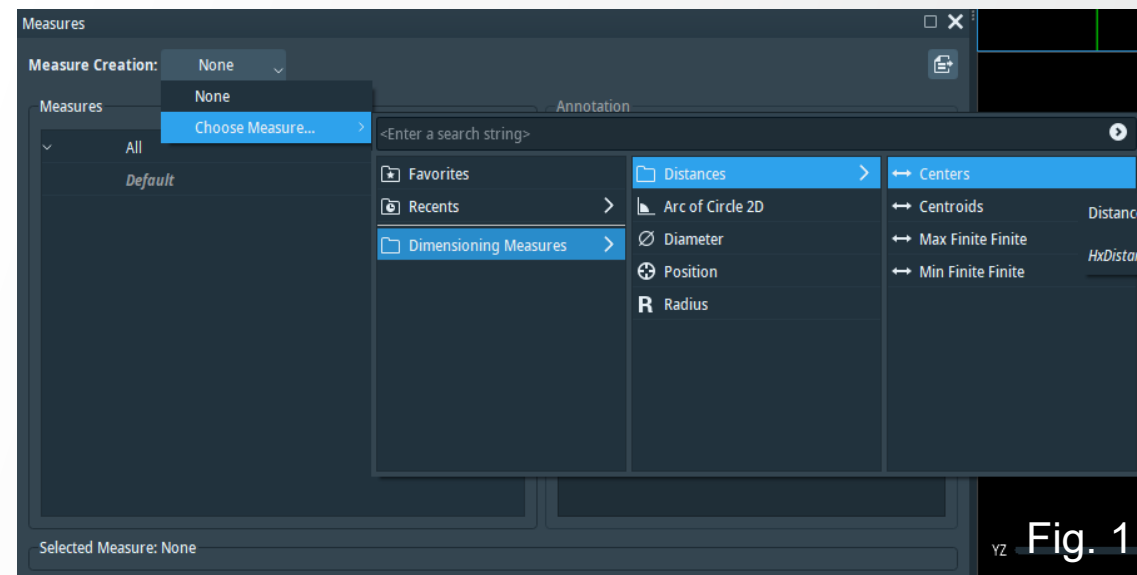
Measuring the sphere to sphere centre distance

Measuring the distance

To measure the distance from the centre of sphere 1 to the centre of sphere 2 select the Measure Creation / Choose Measure... / Dimensioning Measures / Distances and then Centers, as shown in Figure 1.

In the Measures panel the option of choosing which spheres are used is given by a dropdown menu (Figure 2). In the example, only two spheres are shown. For multi-sphere spatial targets, each sphere combination must be chosen.

Once the spheres are selected, press the Create button to measure the distance.



Measuring the sphere to sphere centre distance

Viewing the distance measure

Once the measures have been completed, a new measure will appear in the Measures pane (Figure 1).

When the measure (called Centers) is selected, the distance is shown in the viewing windows (Figure 2). These images can be used for screen shots for referencing the measures in later reports if desired.

Press the Finish button (Figure 1) once the analysis is complete. This will now allow you to create additional measures in the case of multiple spheres or features.

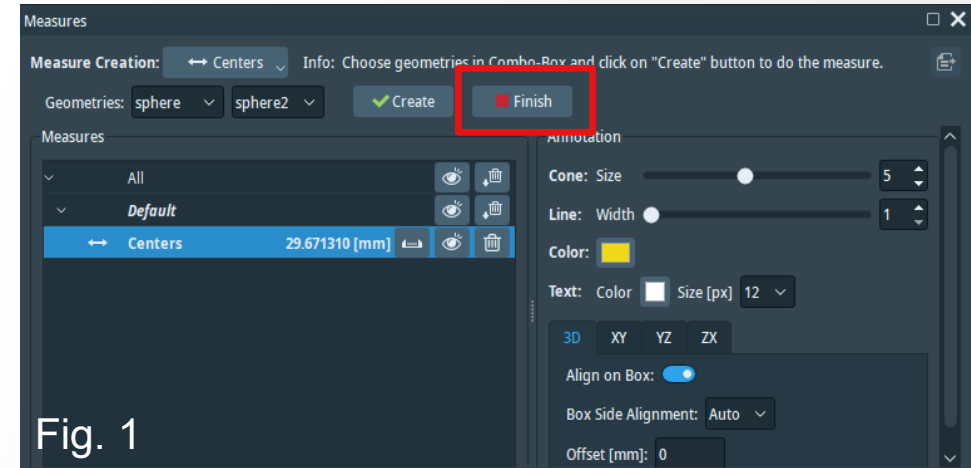


Fig. 1

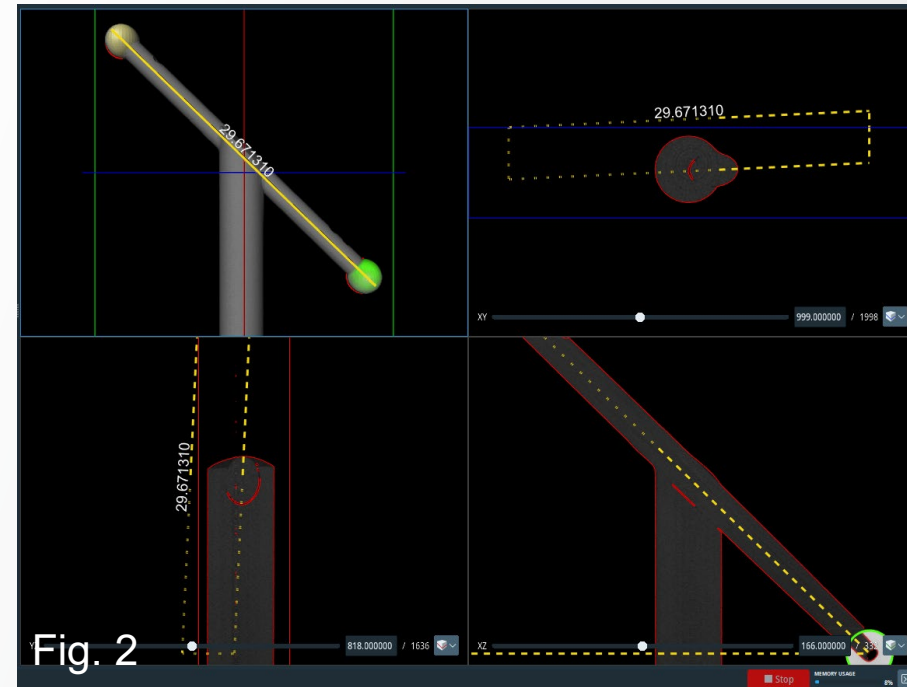


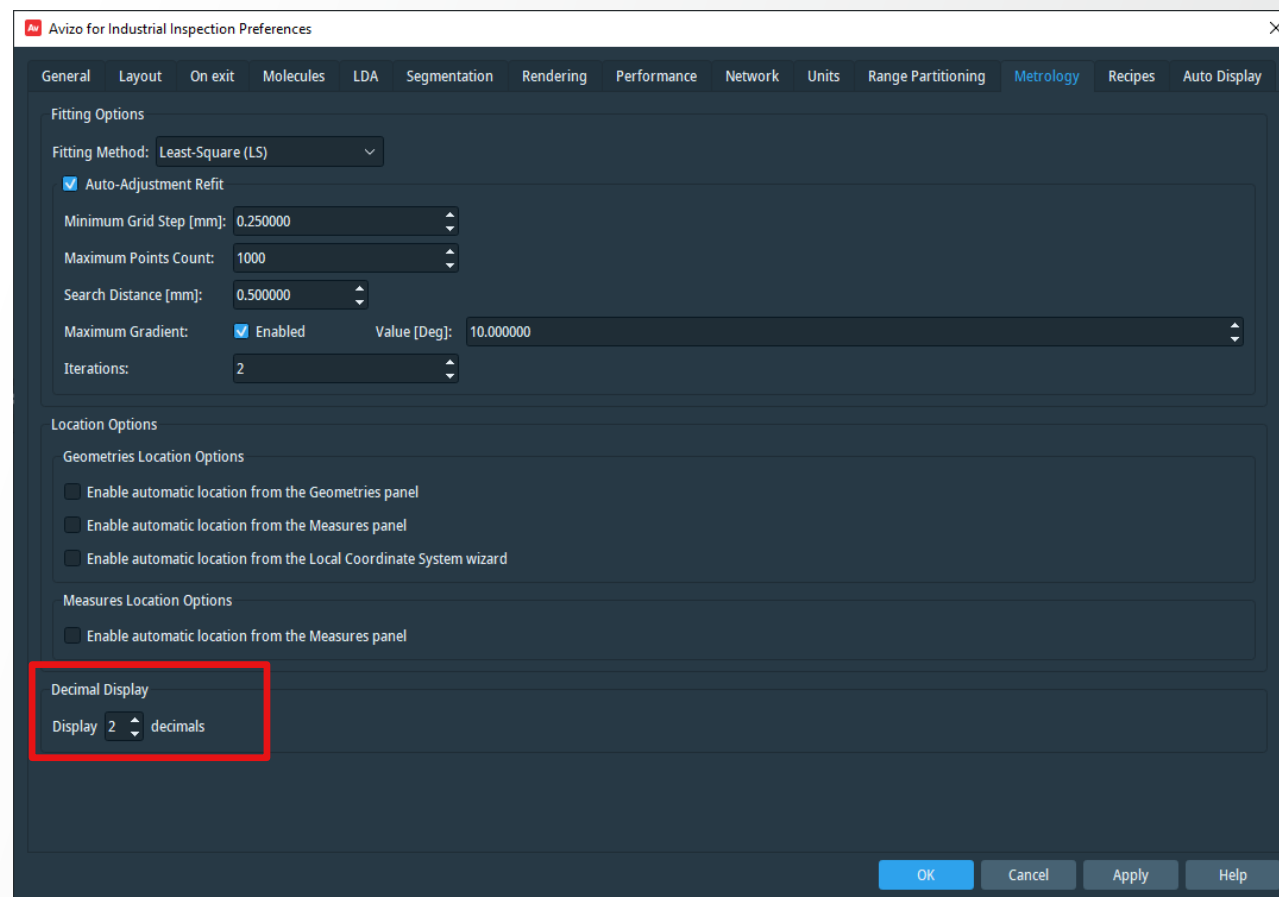
Fig. 2

Measuring the sphere to sphere centre distance

Decimal accuracy preference

Avizo Software will automatically designate the most appropriate measurement scale. In the example this is mm even though the voxel size was imputed in microns. If the measured centre to centre distance does not display the appropriate decimal accuracy:

- Select Preferences in the Edit menu
- Select the Metrology tab in preferences
- Change the decimal display located at the bottom of the page.



How the data can be used in X-ray CT

Conclusion

All the measures can be exported using the export button located in the top right hand corner of the Measures panel (Figure 1). When moving back to the Project workroom, a new spreadsheet data can be found in the Project View (Figure 2).

The sphere centre to centre distance can then be compared with the calibrated distance for the target to produce a more accurate voxel size when measuring features. This will only be valid for scan data taken in this setup. If the manipulator, source or detector are changed (including moving back) then it will no longer be valid due to encoder accuracy on non metrology systems.

If this measurement is part of an exercise to determine a more accurate focal spot to detector distance then the exercise must be repeated at multiple magnifications.

