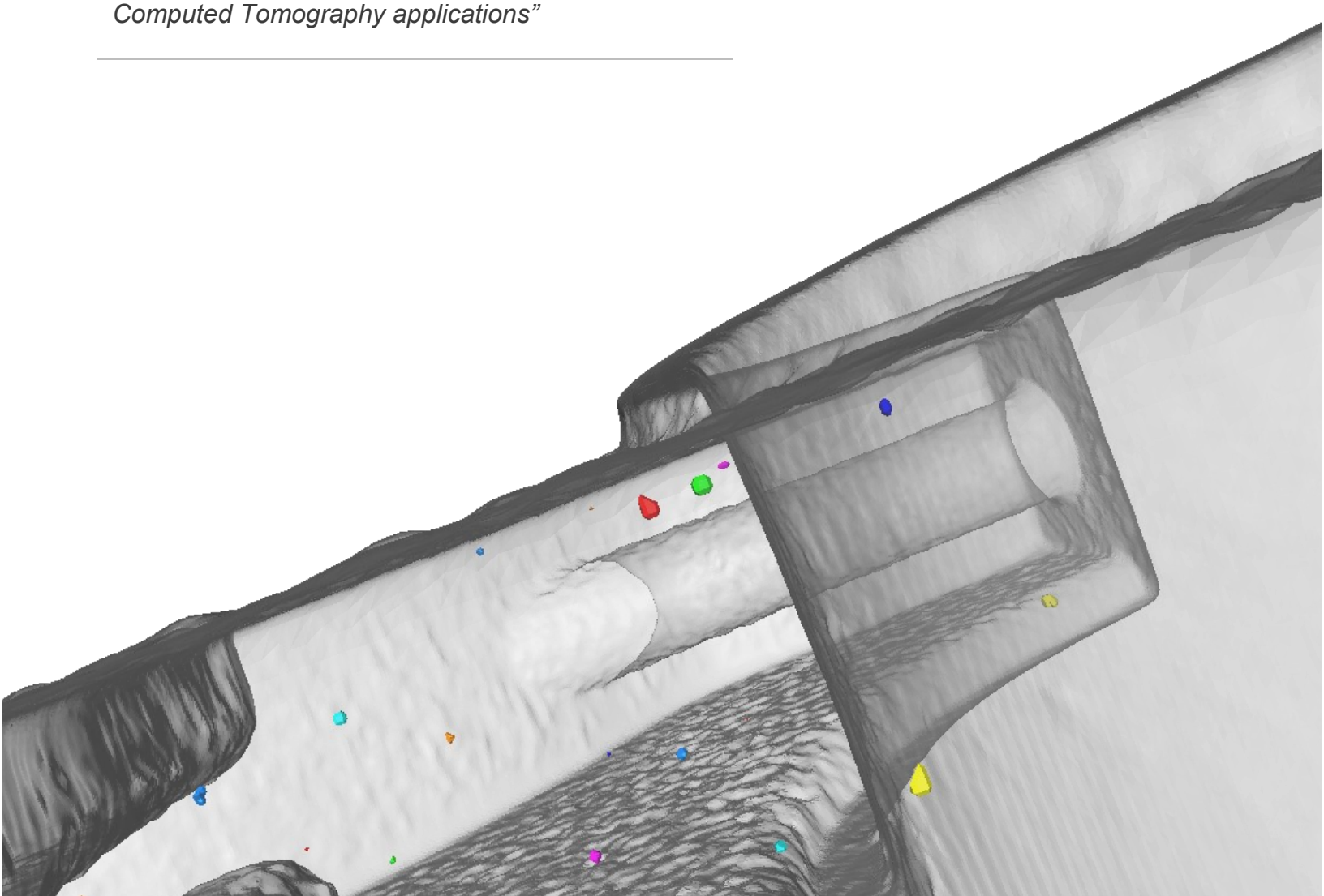
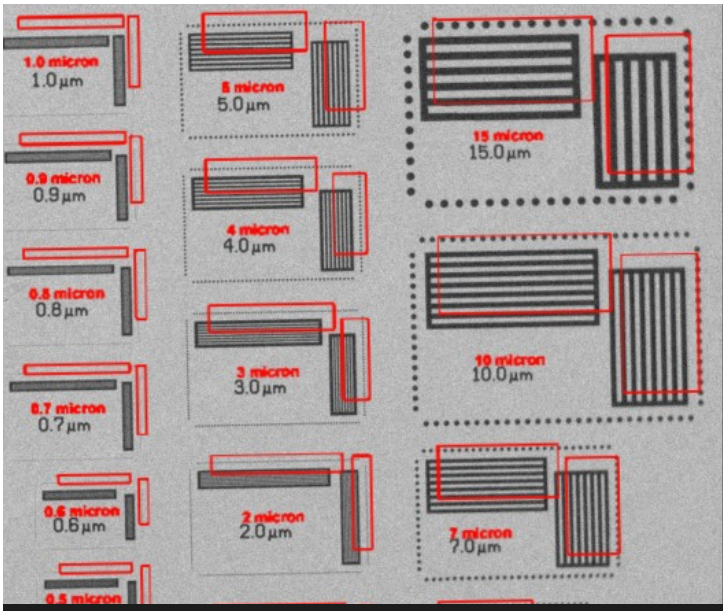
Aletheia

IMAGING SOLUTIONS

"Our goal is to provide high quality Representative Quality Indicators (RQIs) and software solutions to enable measurement confidence in industrial X-ray Computed Tomography applications"

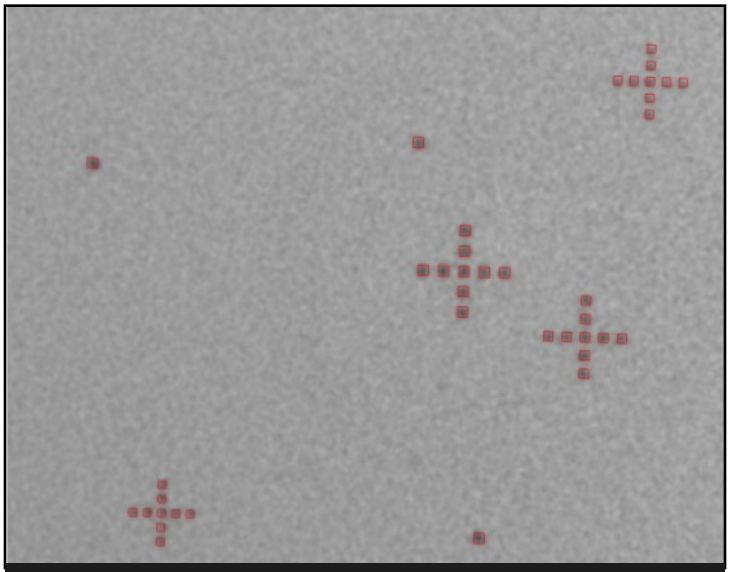


Determination of defects within a component analysed using X-ray Computed Tomography



Template matching to commercially available 2D radiographic & 3D X-ray CT phantoms

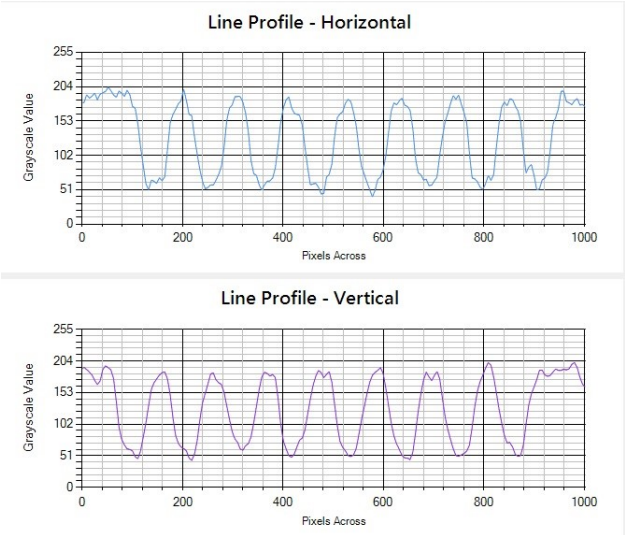
The Aletheia software provides a **user friendly** template matching system that can scaled to the required scan magnification. The user can use an **automated scaling and matching** of the phantom template to the scan data or can opt to manually change the alignment parameters. Templates for extracting numerical information can be produced for both **commercial and bespoke IQI's**



Template matching for an orthoslice of an Aletheia X-ray CT phantom

Software analysis

The analysis of X-ray CT data to determine the **measurement confidence** of defects can be a difficult and time consuming task. Aletheia software provides a **quick** and **easy solution** for extracting **numerical data** from radiographic and X-ray CT **Image Quality Indicators (IQI)**. Data analysis can be defined using standard profiling methods or ASTM industry standards.

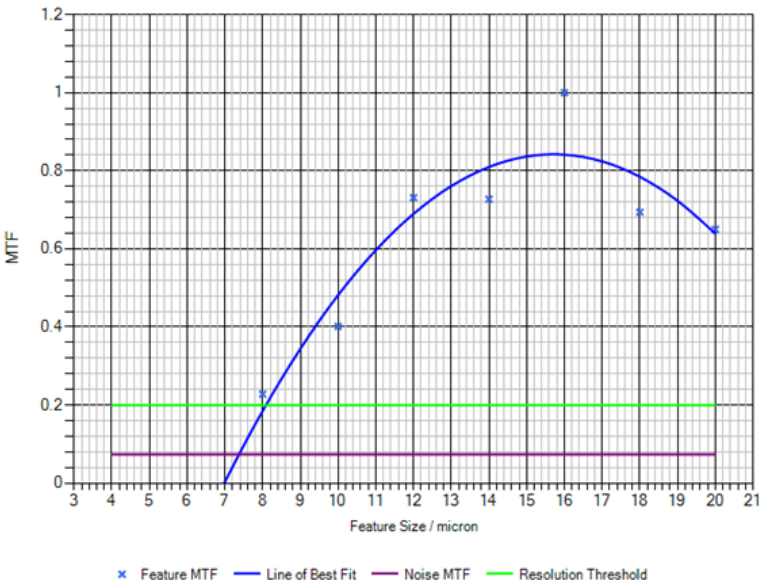


Automated raw data profiling for 2D & 3D X-ray CT phantoms

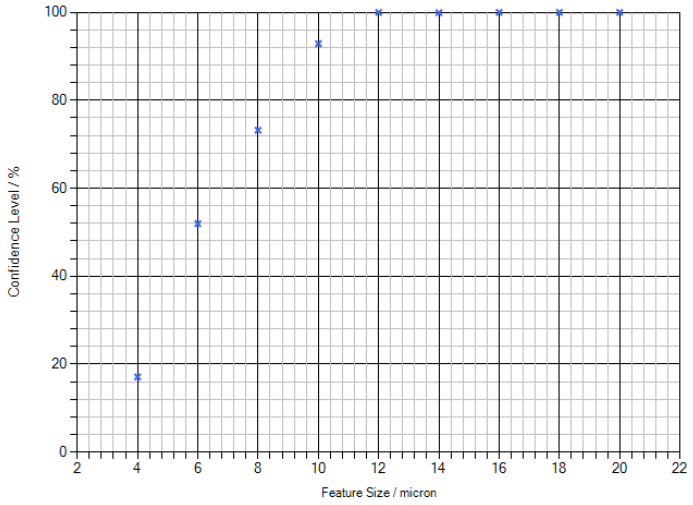
Aletheia software **automatically extracts line profile data** from the radiograph (2D) or orthoslice (3D) IQI. Complex IQI designs such as the Aletheia star that contain over 800 individual features **can be analyzed in seconds**. Raw feature profile information can be analyzed in the software package or exported as a CSV file for independent analysis.

Spatial resolution

Aletheia software can **extract and sort** hundreds of individual profiles from 3D or 3D IQI. The user can define the specific **spatial resolution calculation** from a range Signal to Noise (**SN**) or Modulation Transfer Function (**MTF**) calculations. The spatial resolution cut off such as the **ASTM E2002-15** can then be applied to define the spatial resolution.



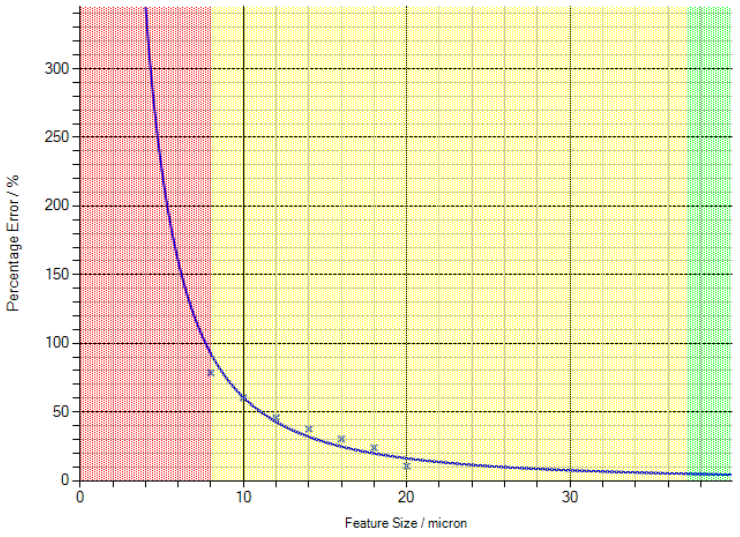
Above: Spatial resolution for a scan of an Aletheia Ti galaxy IQI with features ranging from 4 to 20µm



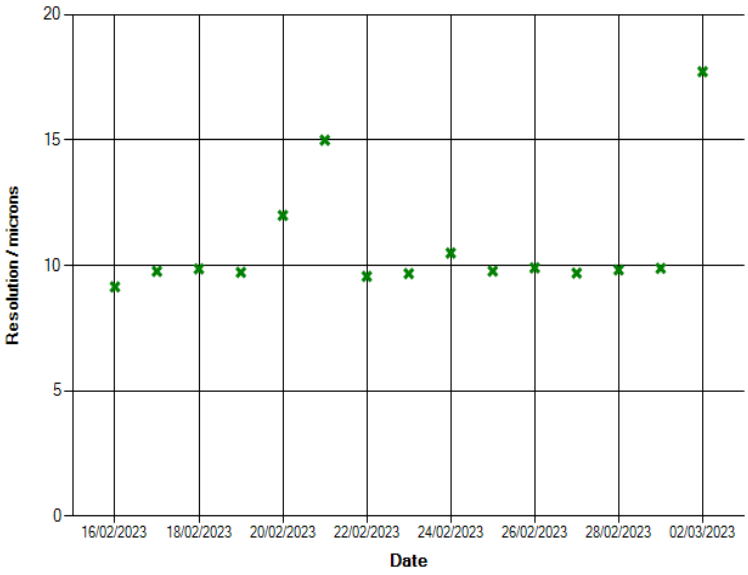
Left: Measurement confidence for features ranging from 4 to 20µm on a 4mm Ti Aletheia galaxy IQI

The Aletheia software calculates the **measurement confidence** level based upon the statistical probability that a measured feature can be distinguished from its neighbour. In the example above the spatial resolution limit is 8.08µm with a measurement confidence of 71.25%. For features above 12µm the measurement confidence reaches 100%.

Features close to the spatial resolution threshold are usually only a few microns or less in size. This means they can be identified but not measured accurately. The Aletheia software can determine the resolution threshold (Red), the range over which features can be detected (yellow) and the region where measurement error falls below 5% (green) as shown on the right



Above: Measurement error for feature size for a X-ray CT scan of a 4mm Aletheia galaxy IQI

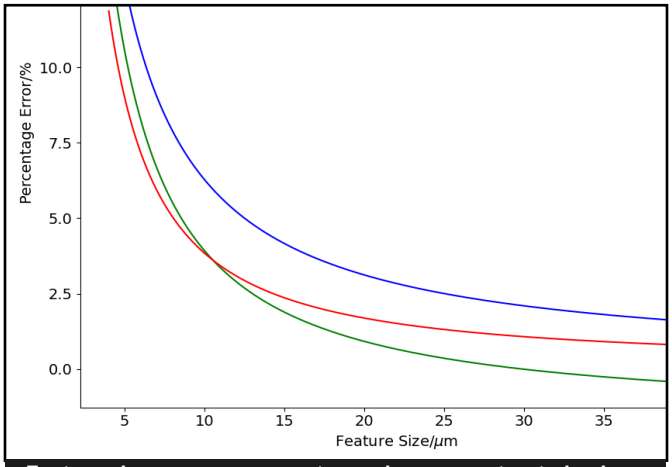


Data tracking of the spatial resolution of an X-ray CT instrument using the Aletheia galaxy IQI

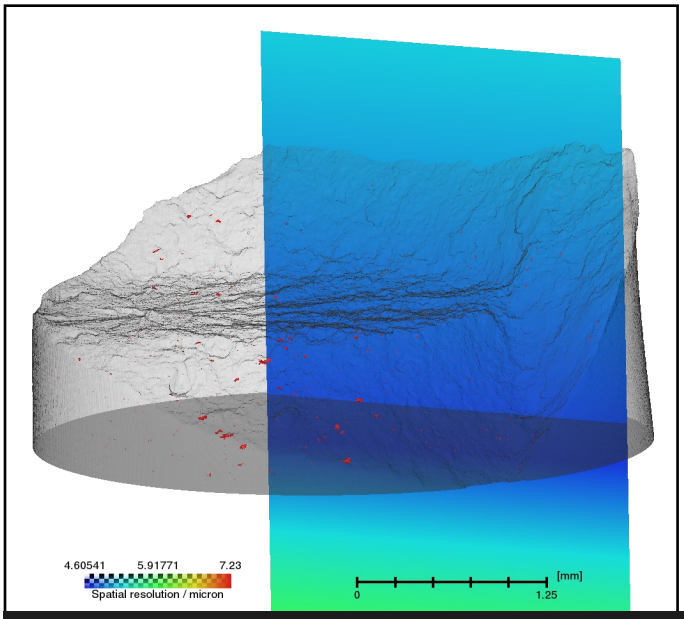
Data tracking

For each 2D or 3D IQI analysis the Aletheia software produces a clear report detailing the spatial resolution and measurement confidence findings. These reports are used in the software to produce a temporal study of instrument performance. This feature enables the quick assessment of instrument health and ensures instruments are working to specified guidelines.

In combination with Aletheia IQI's, the software can take multiple profiles across the detector along the y axis. This information can then be used to create a 3D spatial resolution map for the reconstructed volume. This feature allows a bespoke spatial resolution to be applied to each reconstructed slice of a component **maximising non-destructive evaluation** for greater data analysis accuracy.



Feature size vs measurement error in a reconstructed volume using multiple IQI X-ray CT scans

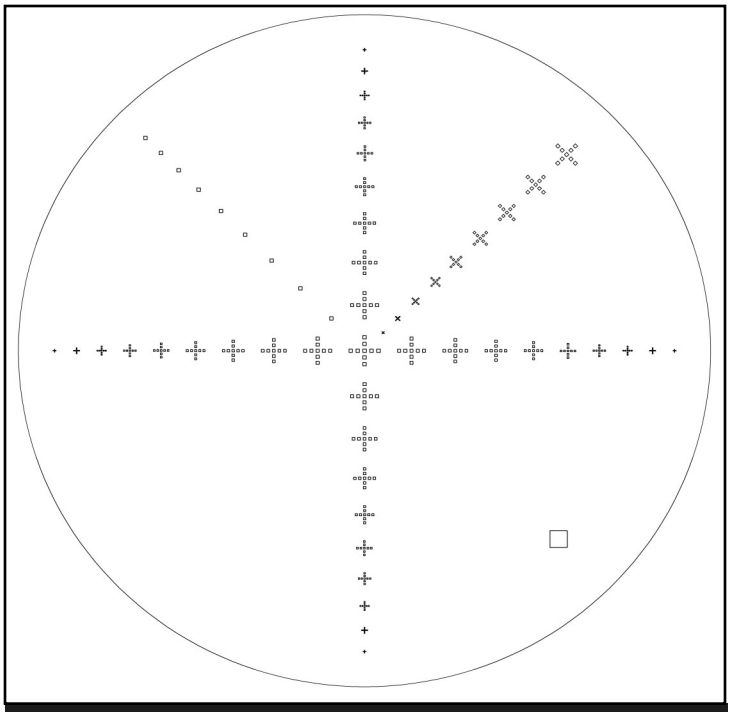


3D spatial resolution map applied to a scan of a 3D printed part

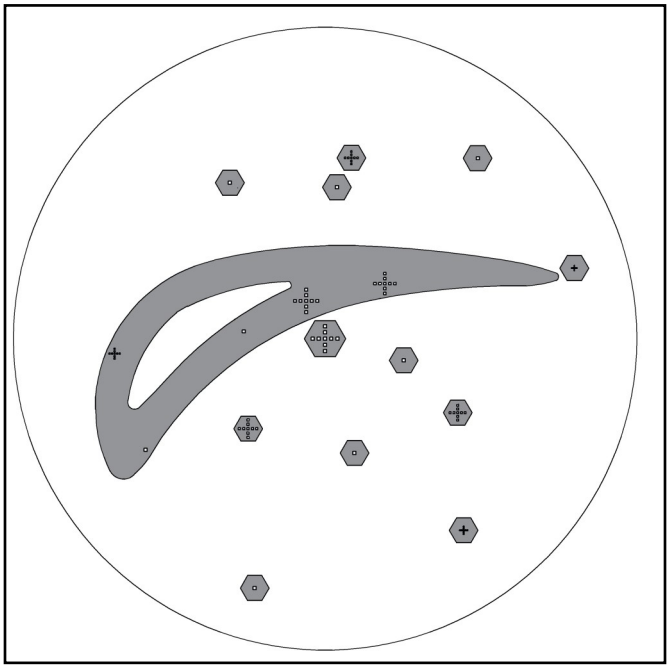
Aletheia software provides a simple overview of **measurement confidence**, **spatial resolution** and errors for specific setups which can be used to refine X-ray CT scan parameters. Reconstructed volume measurement confidence and error analysis can be imported directly into **VGStudio**, **Dragonfly**, **Avizo** or **ImageJ** for component analysis.

Aletheia phantoms

Aletheia uses a range of patented phantom designs, directly harnessing the fundamental physics behind X-ray CT. The phantoms provide a wealth of numerical information that can be used to understand how scan parameters affect the reconstructed image quality. This information is used in the Aletheia software to calculate **measurement confidence** and **spatial resolution**.



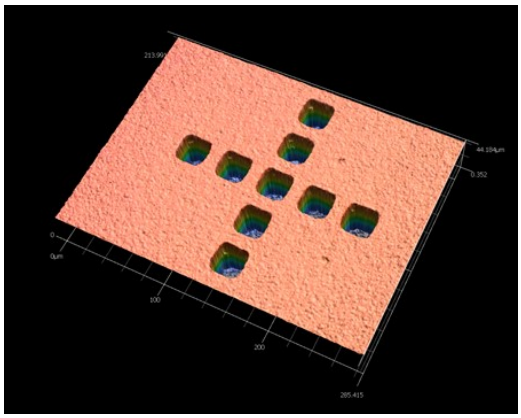
Aletheia star image Quality Indicator (IQI) for X-ray instrument optimisation



Aletheia phantoms can be customised into **Representative Quality Indicators (RQIs)**. These then function as a measurement confidence ground truth for industrial component **NDE**. RQI designs retain the Aletheia galaxy template which can be scaled to a component. The galaxy template ensures all numerical data concerning scan setup can be extracted.

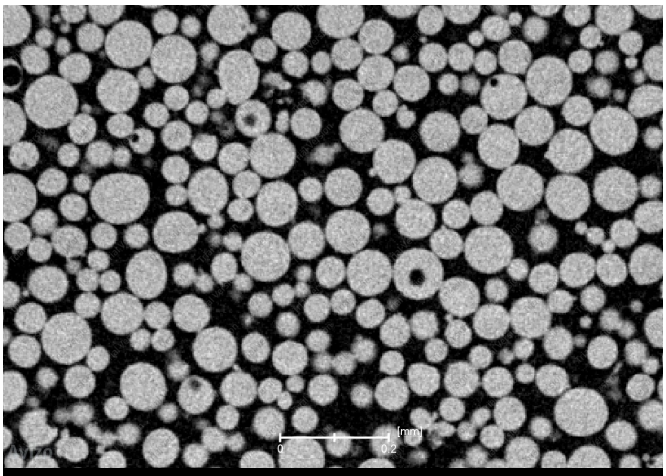
Left: Aletheia bespoke galaxy RQI for a turbine blade

Each phantom is **independently certified** thus forming a **unique fingerprint** that is incorporated into the software for improved measurement confidence. To ensure accurate spatial resolution calculations, Aletheia star and galaxy phantoms have over **1200** and **700** individual measures for **statistical confidence**.

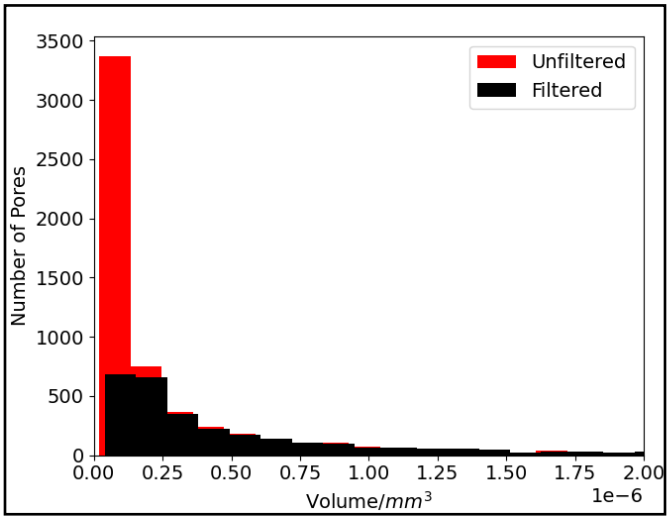


Industry Trial

In **Additive Manufacturing** (AM) metal powder quality is a key criteria in minimising defects. These can include none sphericity, powder clumping, foreign phases and internal porosity. A 4 mm titanium galaxy phantom, with spatial features ranging from **4 µm** to **20 µm**, was used to calculate the measurement confidence and spatial resolution of analysed **titanium** powders. The powder and phantom were scanned on a Waygate X-ray instrument using an effective pixel size of **2.7 µm**. Analysis showed the scan achieved a **spatial resolution of 4.5 µm** in the reconstructed volume. In post processing, over 169000 pores were analysed with 6277 (3.7%) internal pores detected. After calculating the measurement confidence (**98% criteria**) only 3426 pores (2.0%) could be confidently determined to be above the noise threshold.



AM titanium powder with particles displaying internal porosity



Fraction of pores in AM powder particles before and after the application of spatial resolution threshold. All filtered pores met a 98% measurement confidence

Additional information

For more information on how X-ray CT spatial targets are applied in non-destructive evaluation, as well as training information, please visit: **aletheia-solutions.com**

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Technical questions and data analysis: **tristan@aletheia-solutions.com**

Signal processing and software: **sam@aletheia-solutions.com**

Case studies using Aletheia spatial targets

aletheia-solutions.com