How can we be confident in X-ray CT data quality?

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Overview

- Application of oesophageal NiTi stents
- Application of X-ray CT for NDE
- Systems used for comparative Non-Destructive Evaluation (NDE)
- Ground truth for imaging comparison
- Instrument comparison
- Summary

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Application of Oesophageal NiTi stents

Oesophageal stents are usually palliative care devices.

- Average service time of the device is 4 to 6 months
- Patient survival rose from 3 to 16 months
- Loss of material properties and Structural failure
- Increased risk and lower quality of life

Undamaged Oesophageal stent

Damaged Oesophageal stent requiring removal

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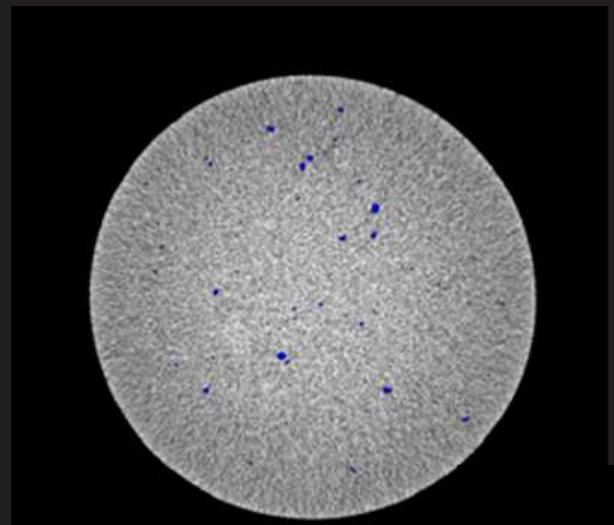
Application of X-ray CT for NDE

Nano and micro X-ray CT systems have the ability to image small defects none destructively

- Ortho slices allow quick identification of defects
- 3D analysis quantitative analysis of the defects and relationships
- Sample preparation can be difficult for sub-millimetre specimens
- Suppressing image noise in high resolution imaging noise



2D Orthoslice

3D rendering of the wire defects

Systems used for comparative Non-Destructive Evaluation

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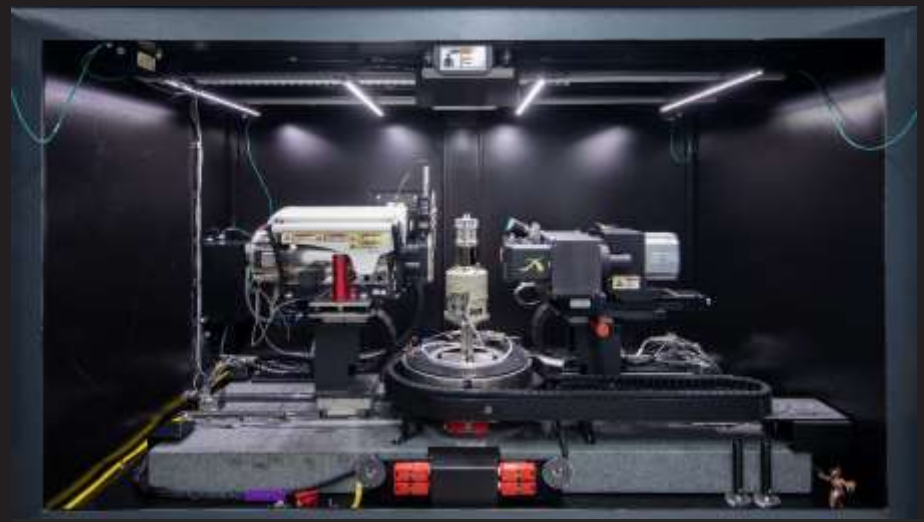
High resolution X-ray CT systems from established laboratories were used in the study:

- 80keV for appropriate penetration
- Effective pixel size of 0.67-0.83µm
- Radiograph acquisition time and pixel counts were as recommended by the supplier or instrument technician
- Source power was either automatically applied or set by the instrument technician



ZEISS VERSA 620 X-ray microscope at the NXCT Manchester

NanoTOM system at Waygate Technologies in Germany

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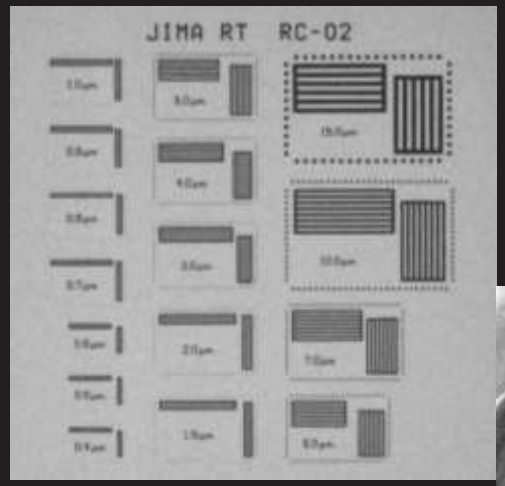
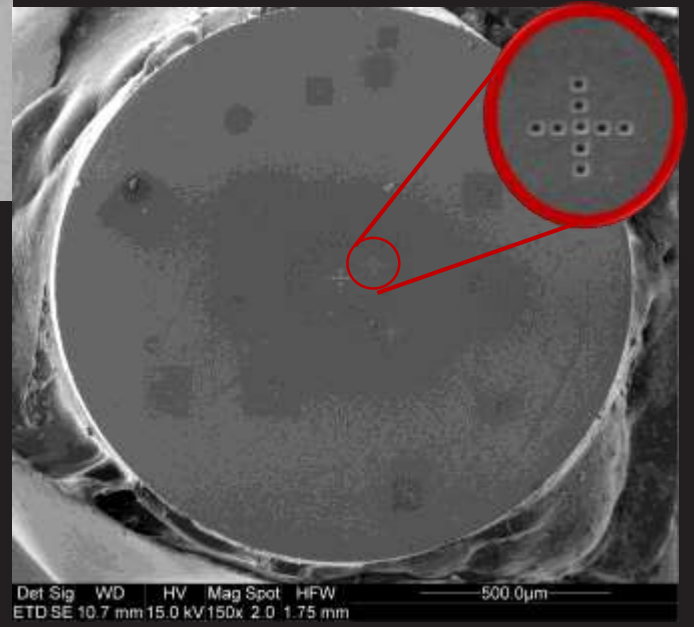
Ground truth for imaging comparison

Image Quality Indicators (IQI) are used within the radiographic testing

- Established signal processing methods for determination of spatial resolution
  - ASTM E1441-19, E1695-20, E2002-15
- ASTM and others have applied these principles to X-ray CT
- Representative Image Quality Indicator (RQI) for the stent wires was produced
- Software by Aletheia was used to quantify CT scan quality



2D spatial targets are useful measures for radiograph image quality



3D spatial targets for measuring the X-ray CT reconstructed image quality

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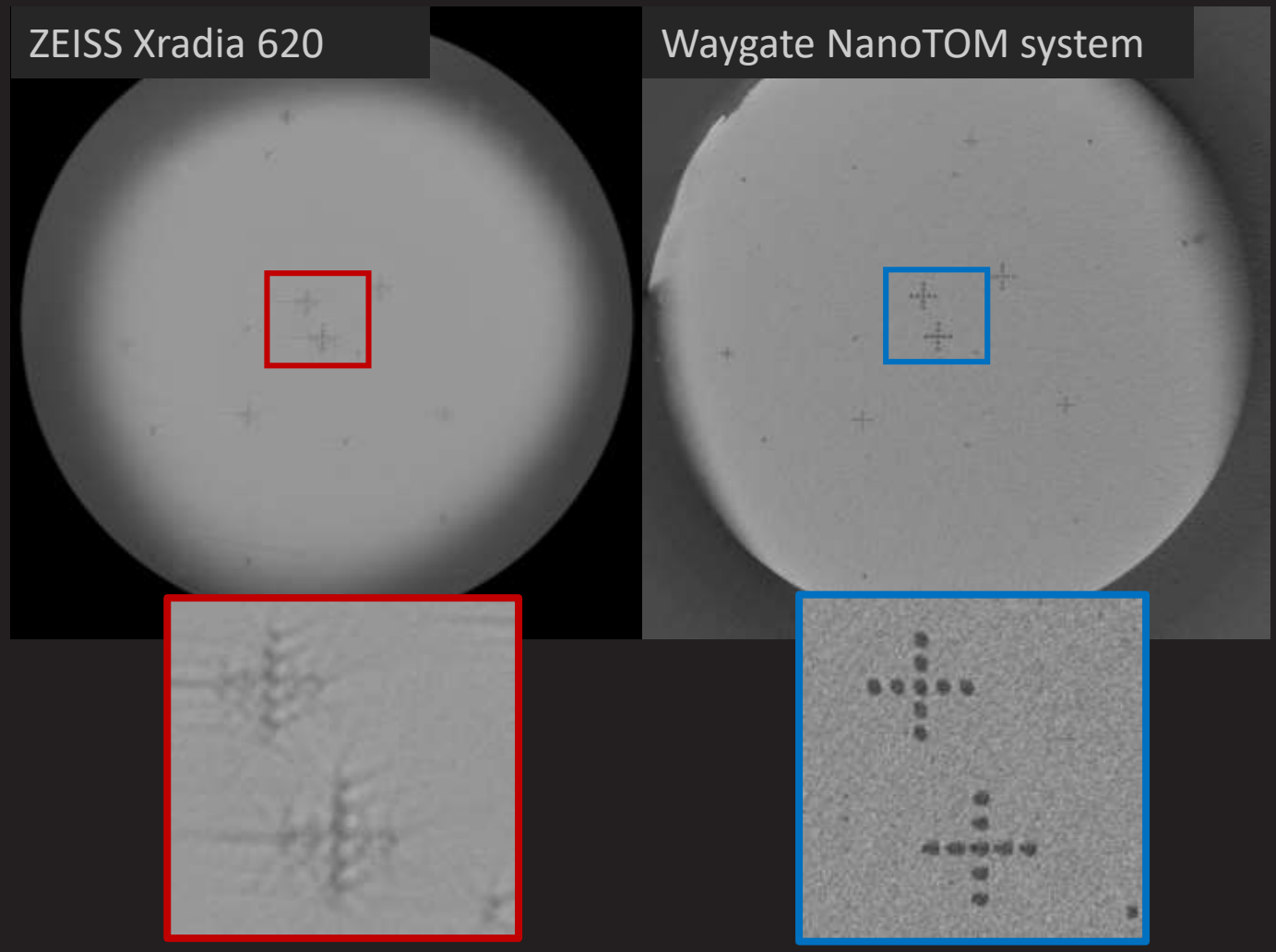
Best achievable resolution

1.5mm RQI with features ranging from 7.5µm to 0.75µm. The full field of view used:

- The ZEISS Versa620
  - 0.83µm Effective pixel size
  - Frame averaging 2
  - Total scan time 21hrs
- Waygate system
  - 0.57µm Effective pixel size
  - Frame averaging 16
  - Total scan time 12hrs



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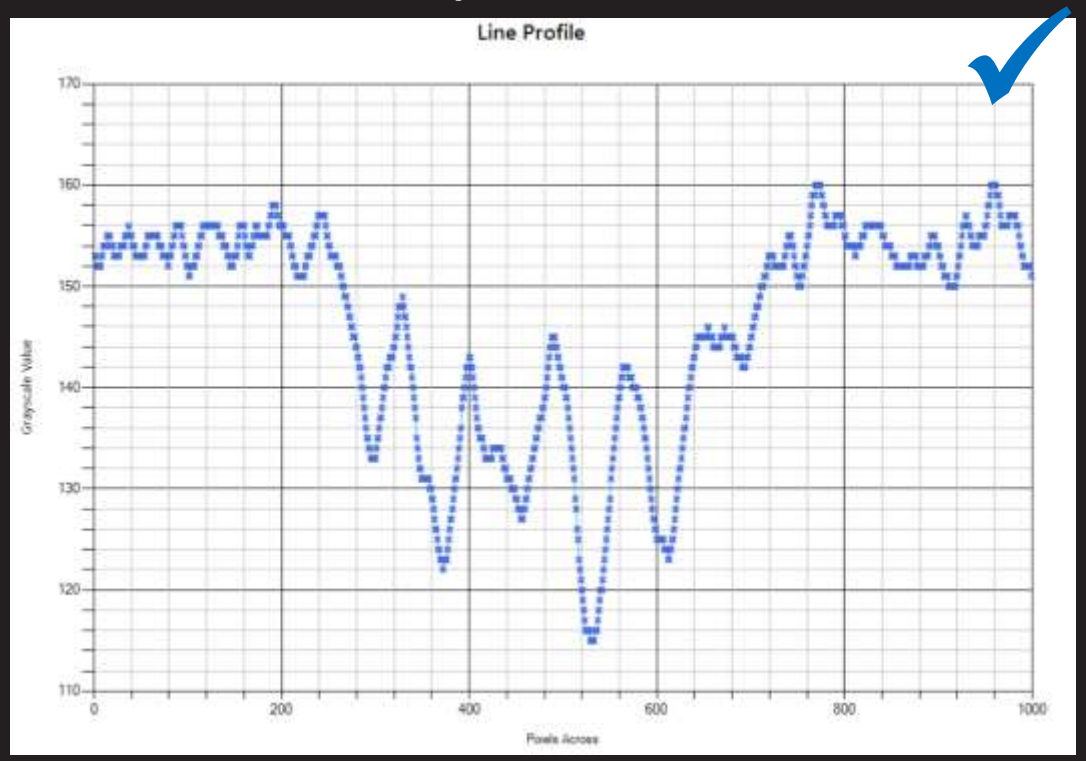
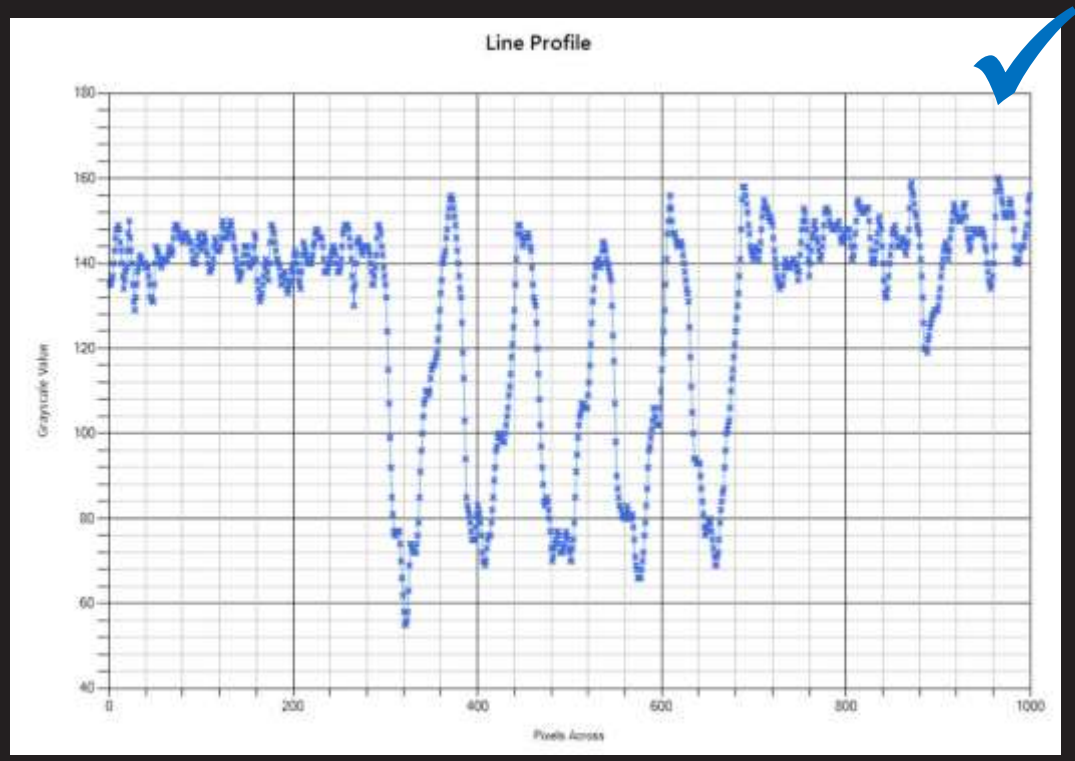
Signal processing

Features: 7.5µm



ZEISS Xradia 620



Waygate NanoTOM system

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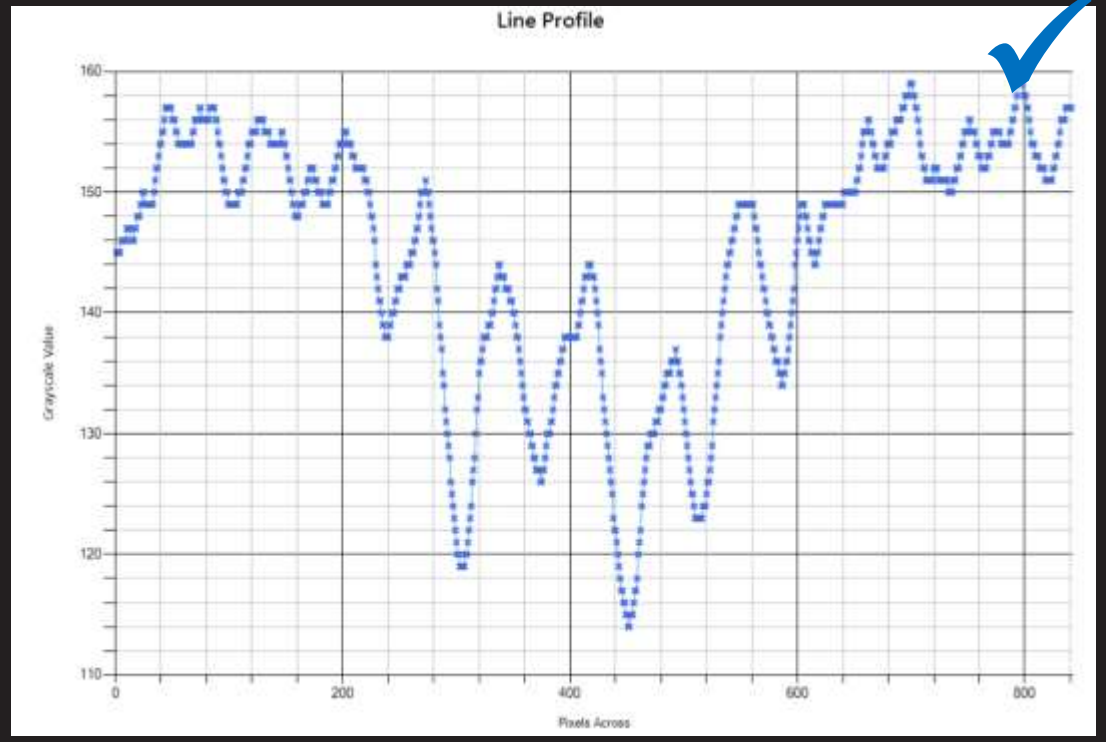
Signal processing

Features: 6.75µm



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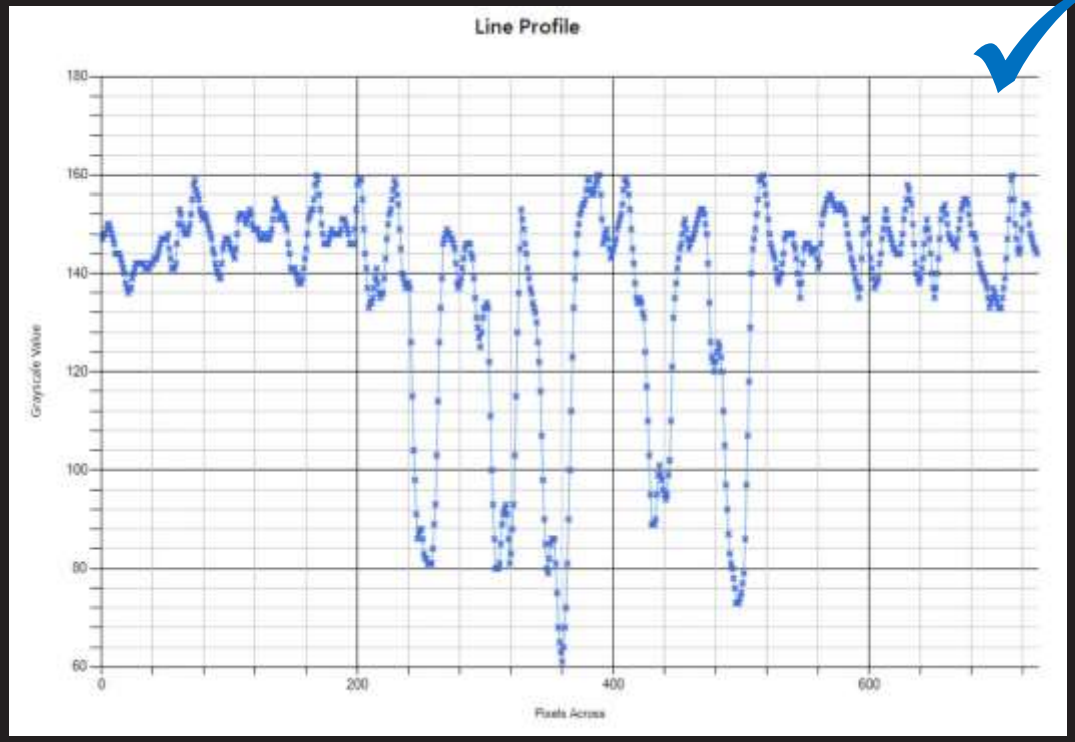

Waygate NanoTOM system

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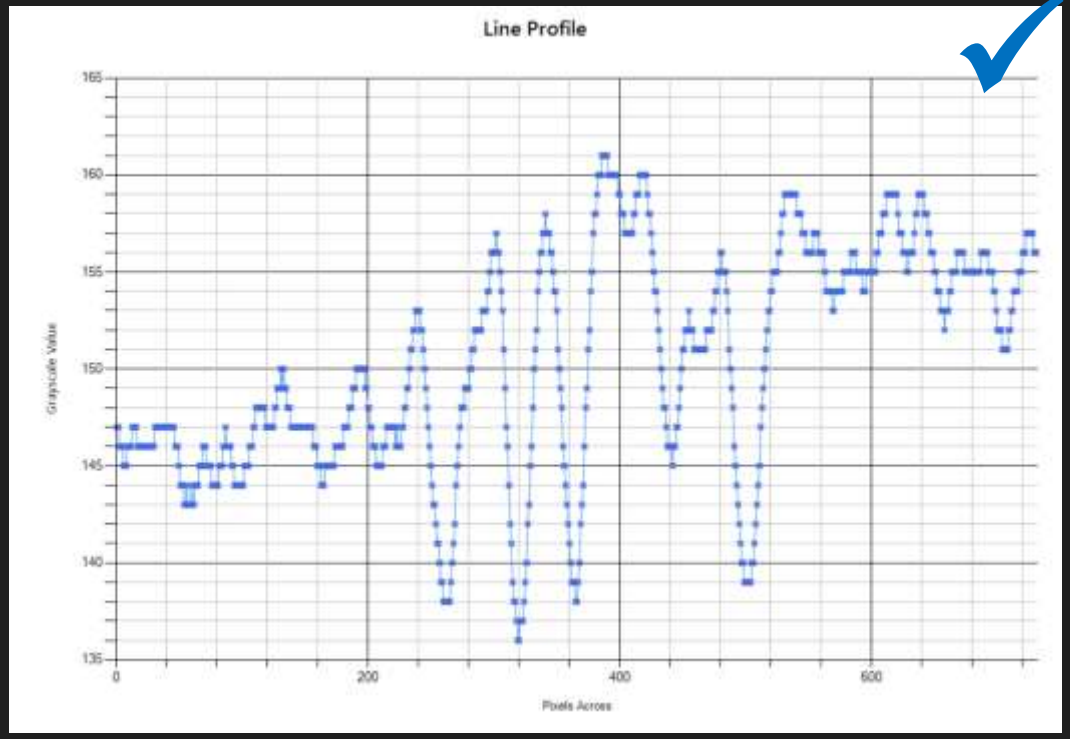
Signal processing

Features: 6.00µm



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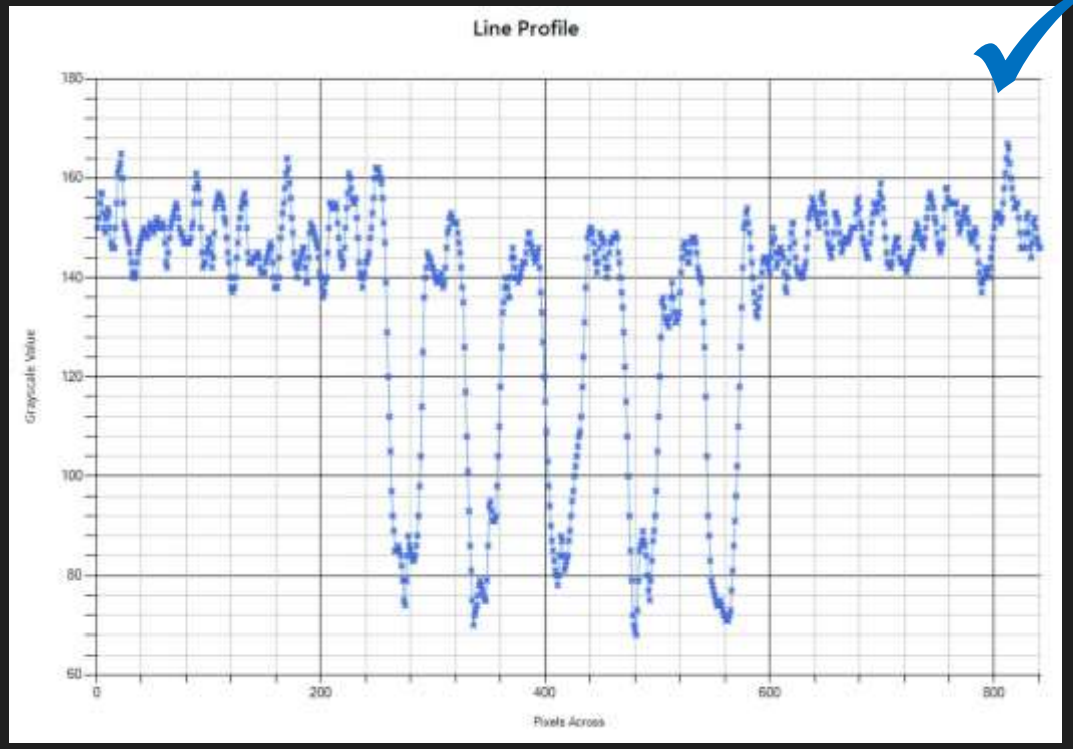

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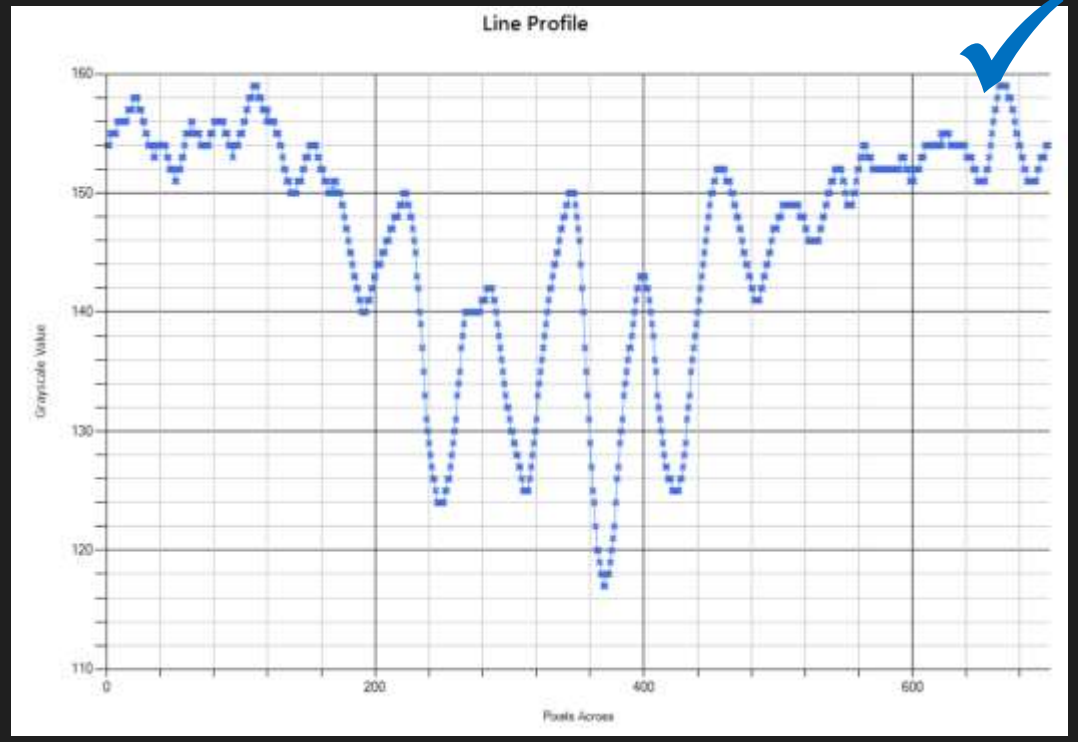
Signal processing

Features: 5.25µm



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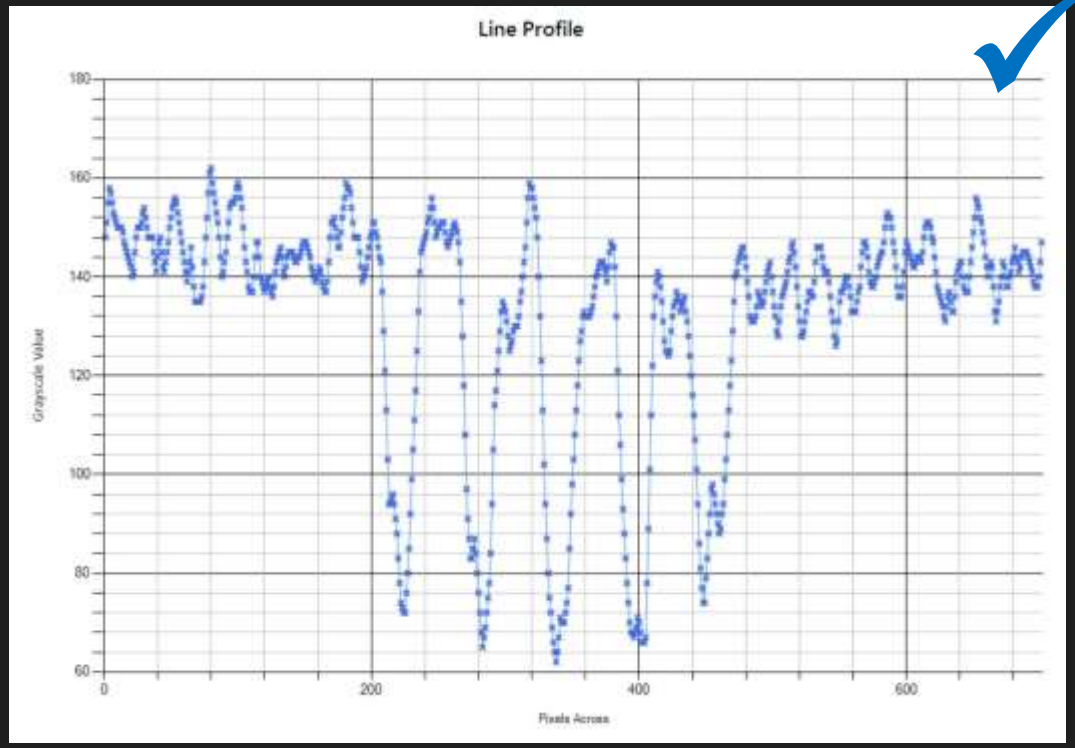

Waygate NanoTOM system

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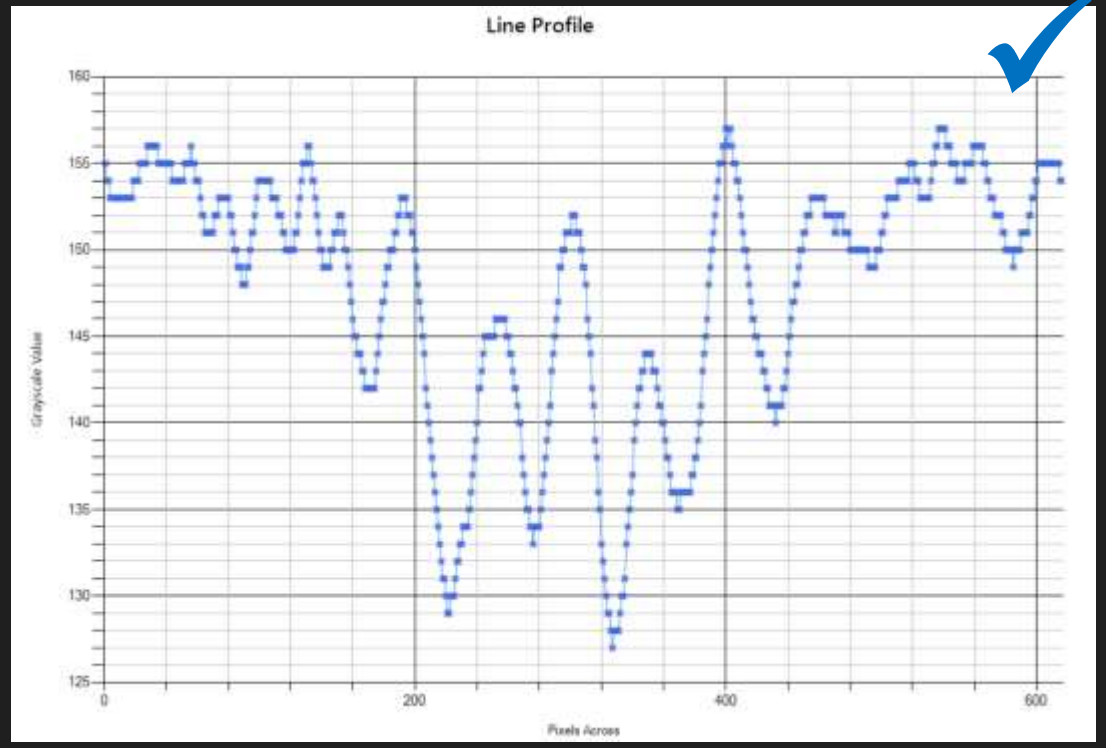
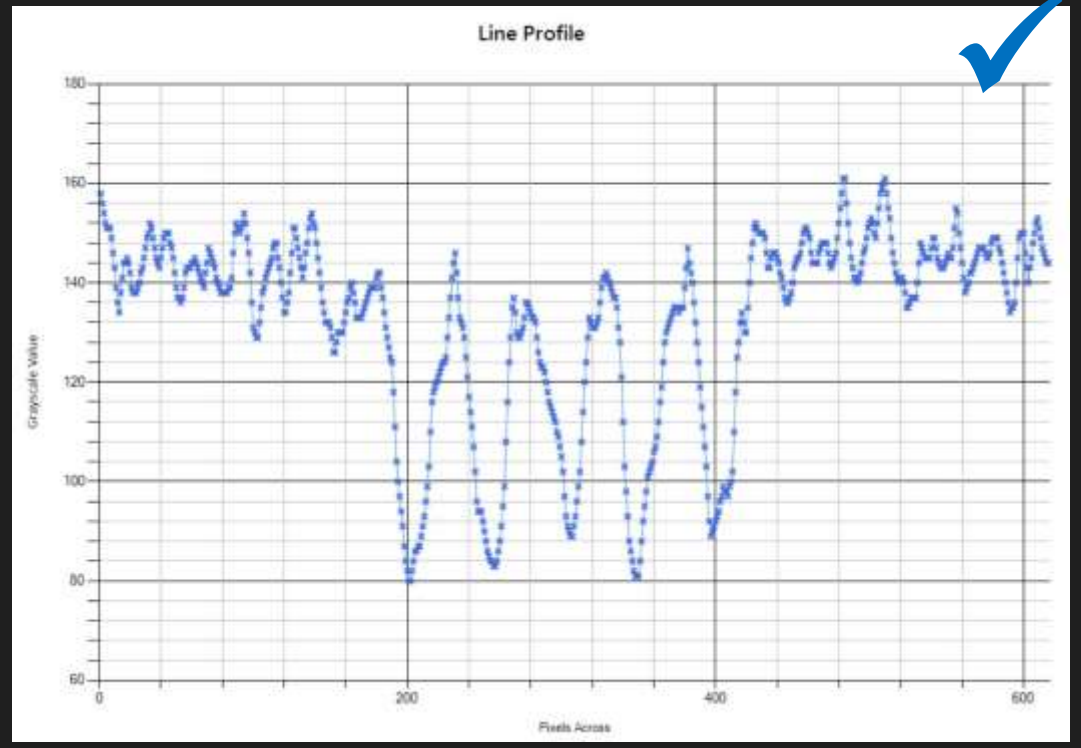
Signal processing

Features: 4.50µm



ZEISS Xradia 620



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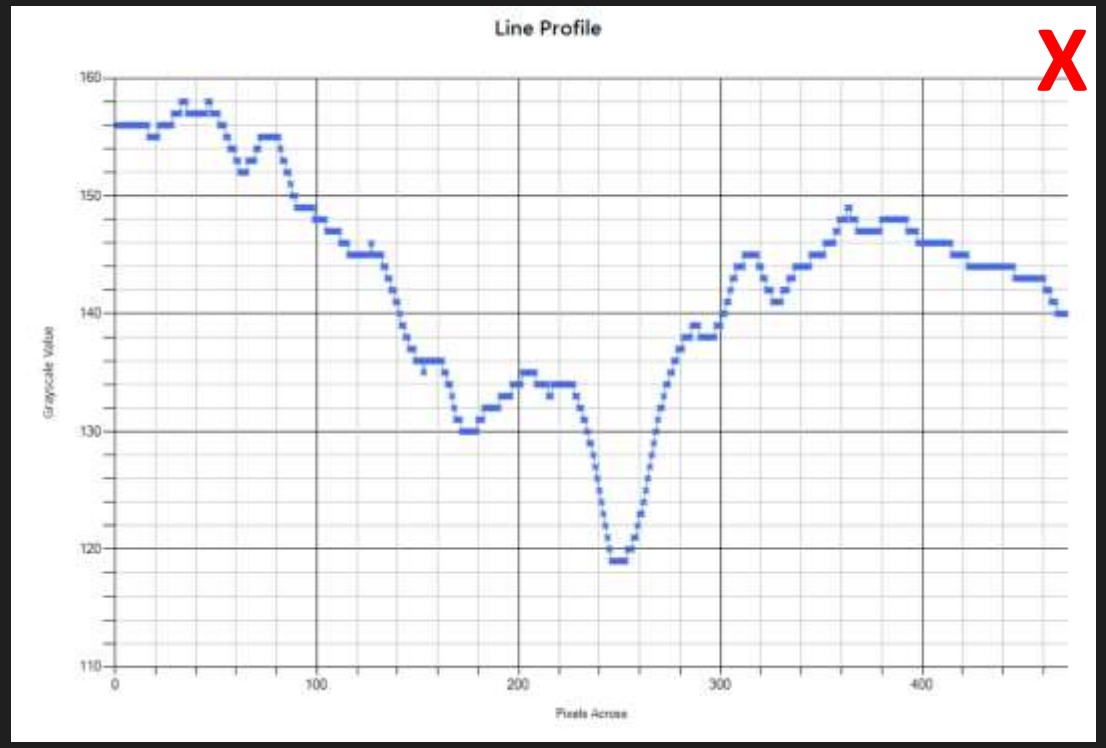
Signal processing

Features: 3.75µm



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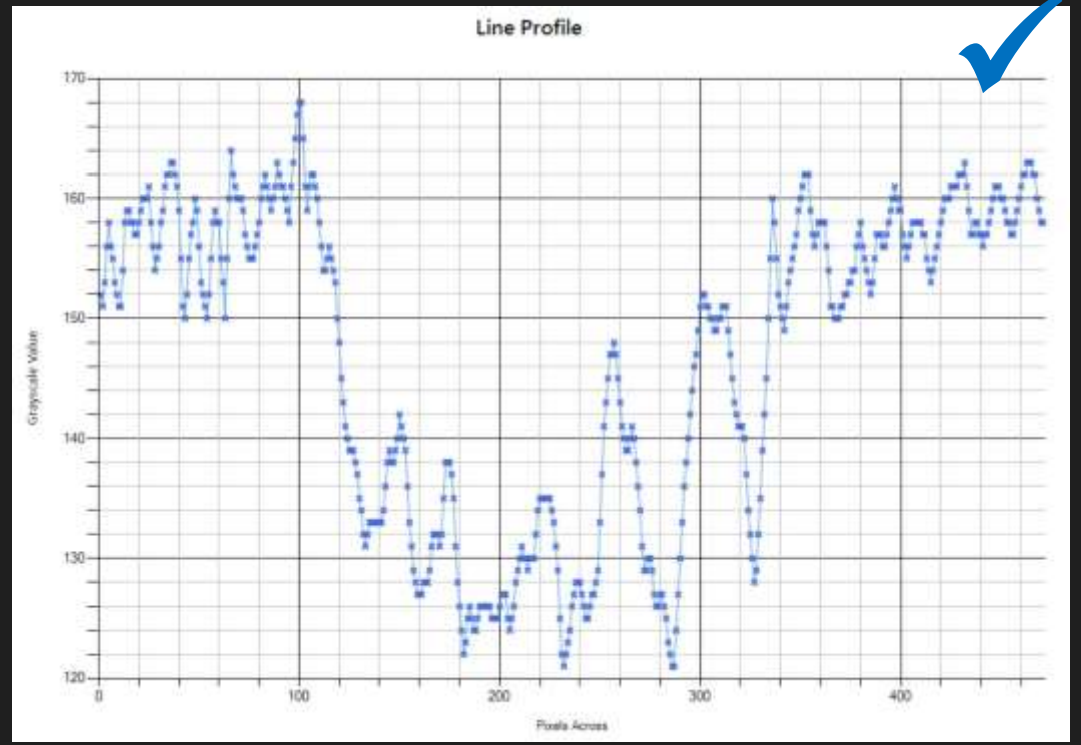
ZEISS Xradia 620



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Waygate NanoTOM system

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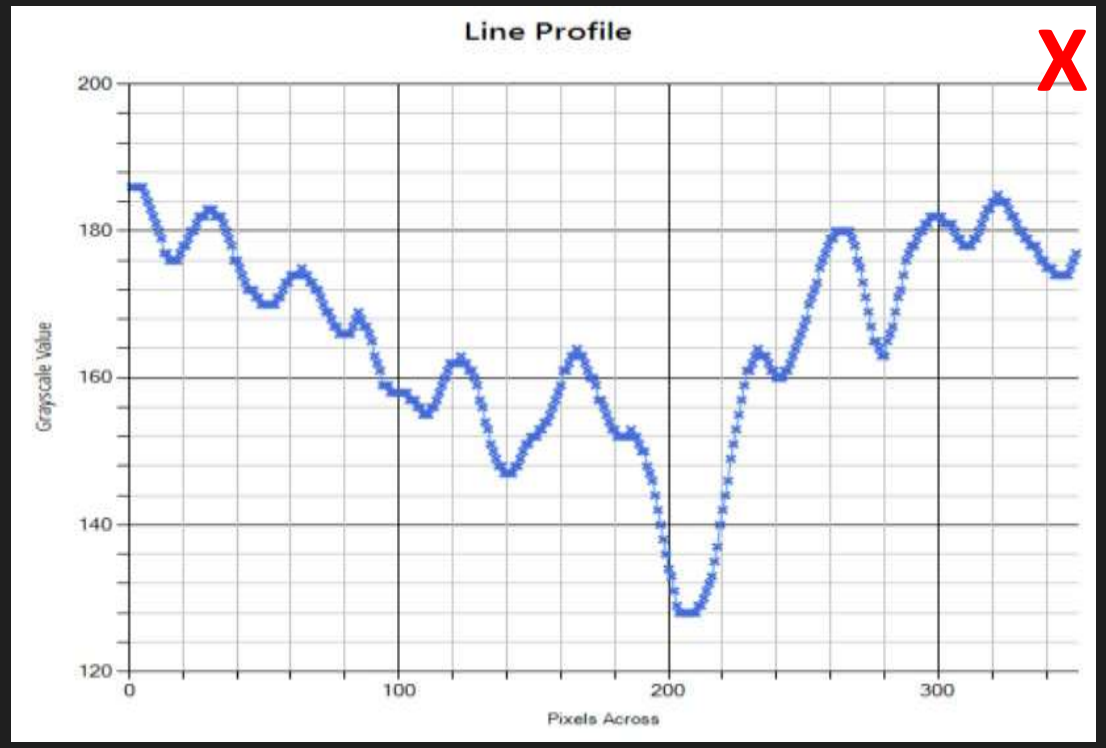
Signal processing

Features: 2.25µm



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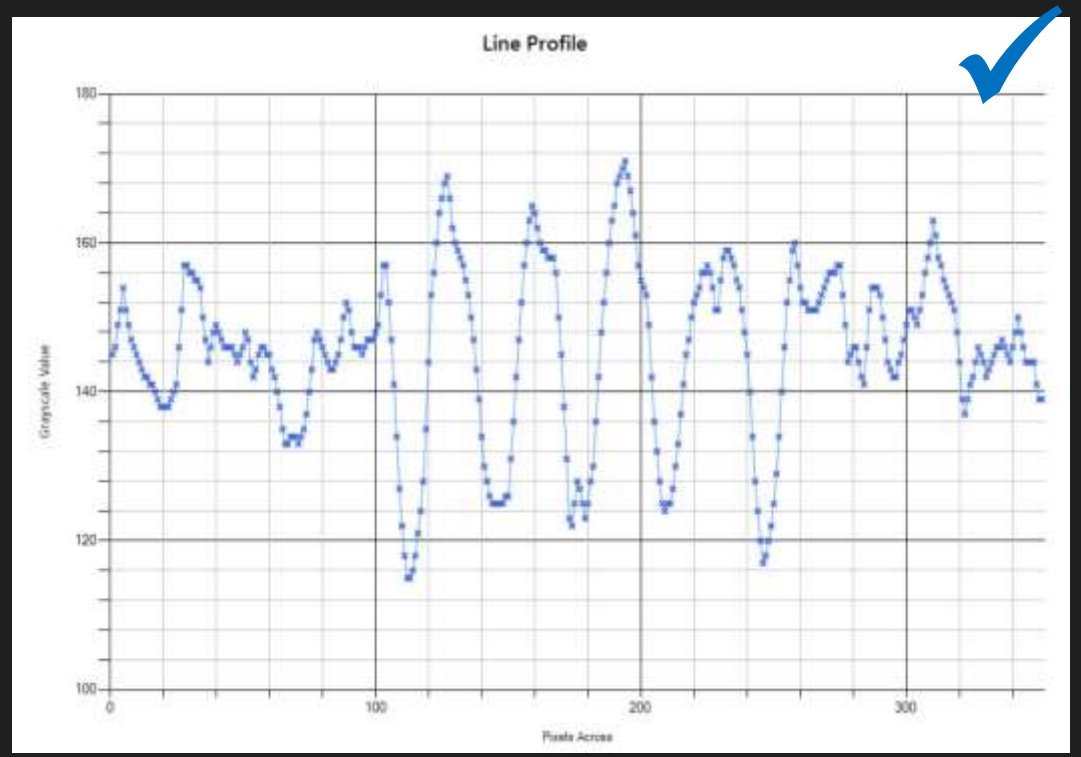

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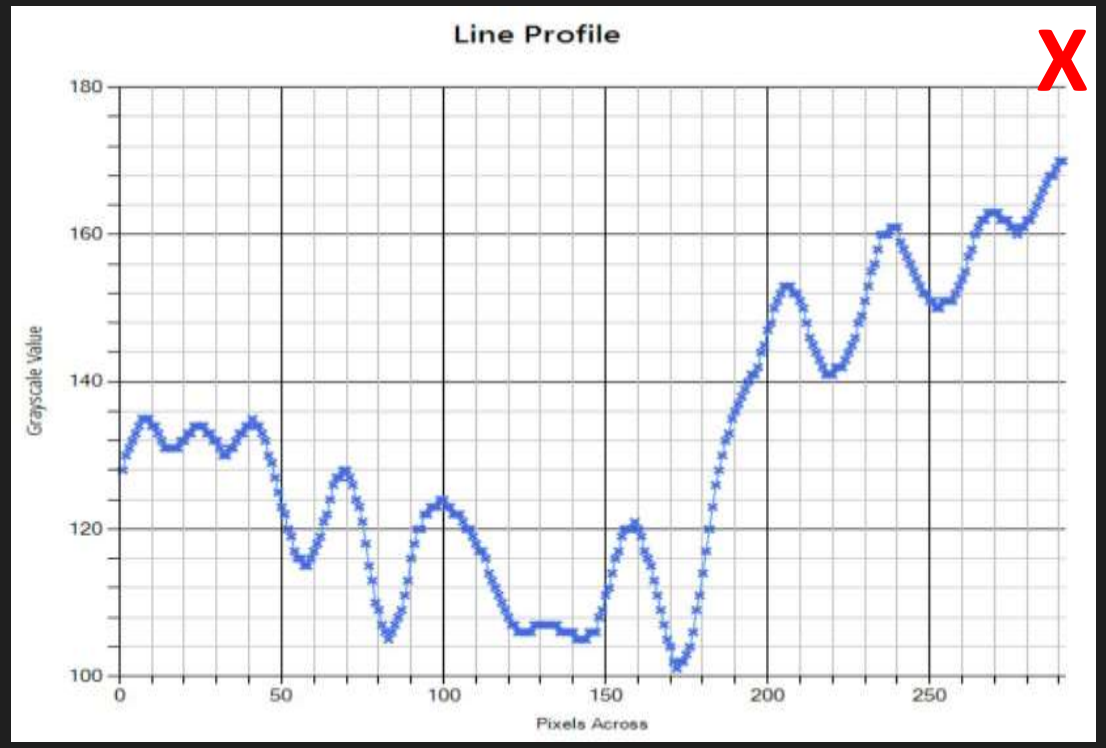
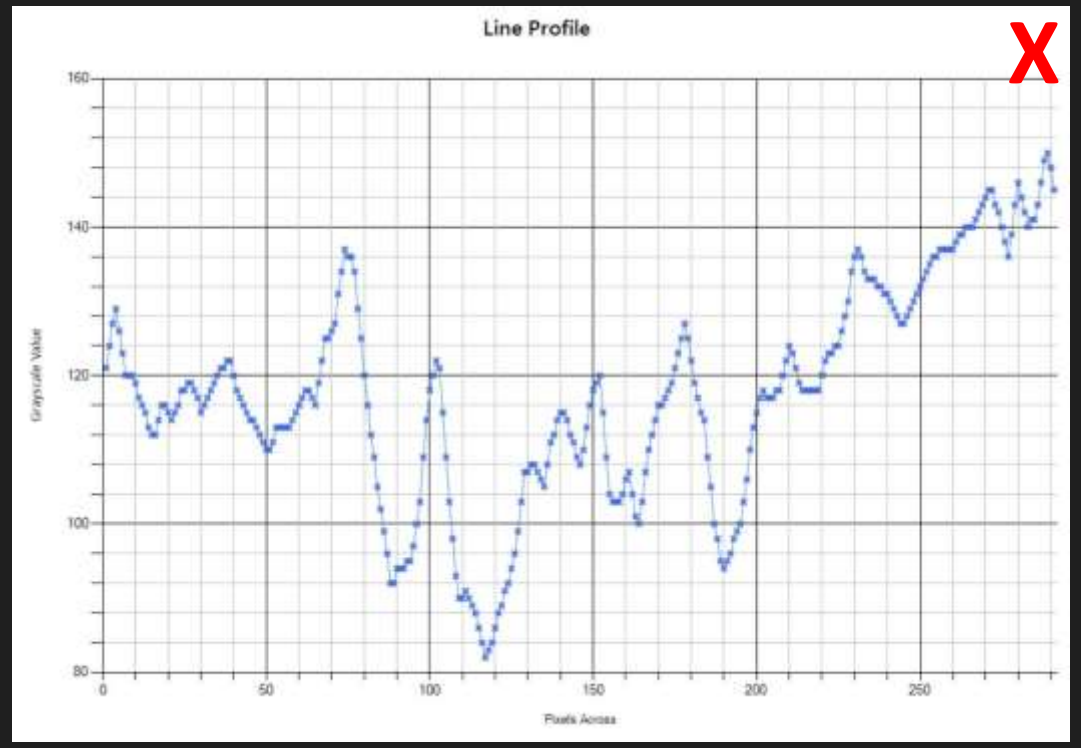
Signal processing

Features: 1.5µm



ZEISS Xradia 620



Waygate NanoTOM system

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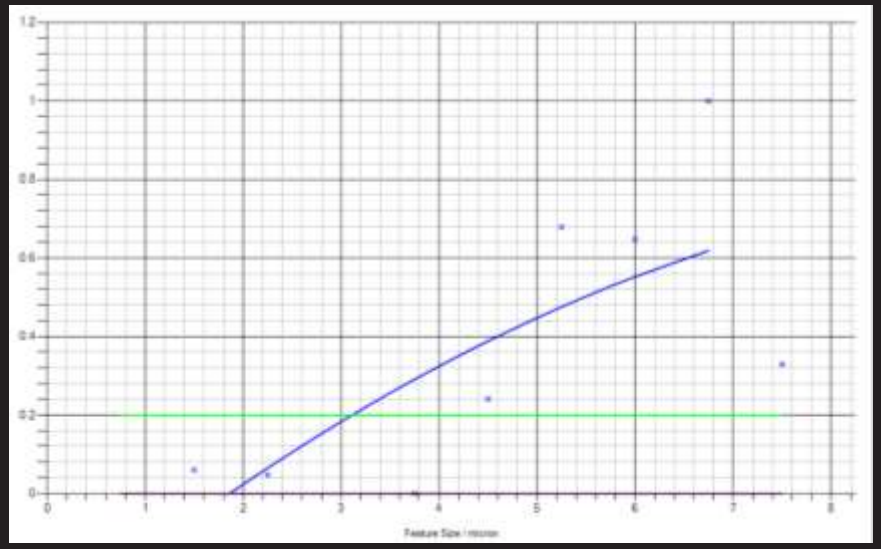
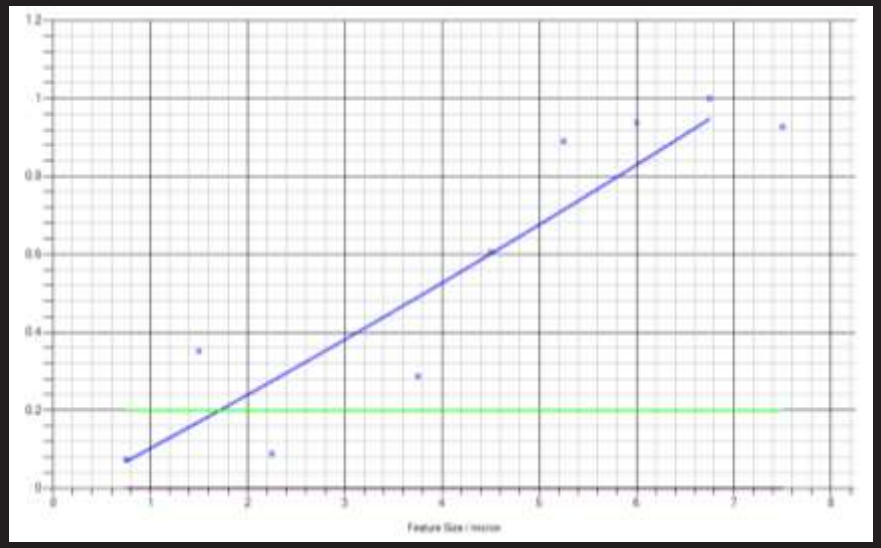
Spatial resolution calculation

Modulation Transfer Function (MTF) calculated using ASTM E2002-15:

- ASTM 20% MTF threshold used for spatial resolution
- NXCT ZEISS 620 achieved 3.1µm spatial resolution
  - Over 1.2X predicted spatial resolution of 2.49!
- Waygate NanoTOM achieved 1.7µm spatial resolution
  - Better than predicted spatial resolution of 2.01µm





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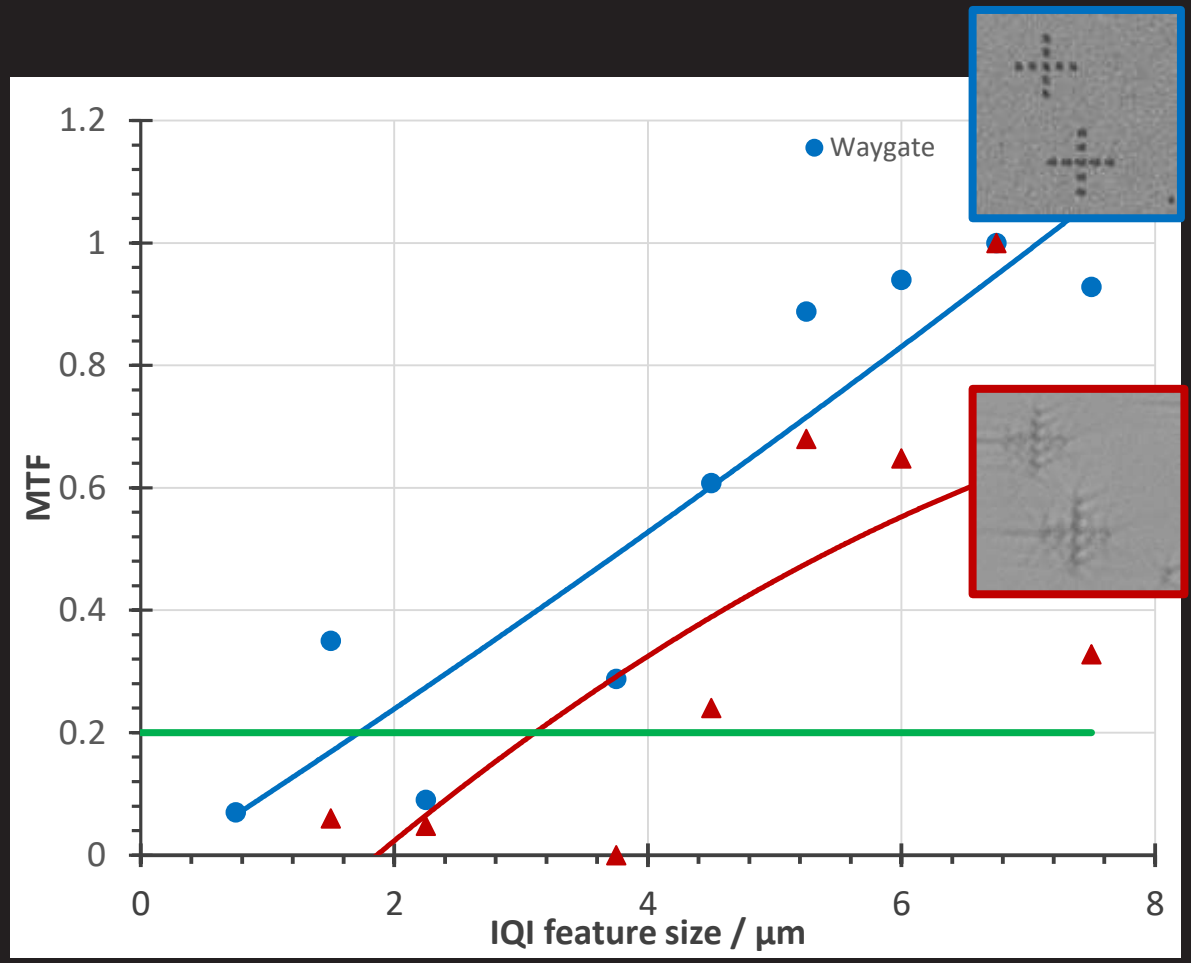
Spatial resolution conclusions

Similar instrumentation can give very different results:

- Signal strength for the Waygate system is significantly higher than the ZEISS 620
- The ZEISS data artefacts caused several software issues and resolution is 4µm
- IQI features show a significant image quality difference



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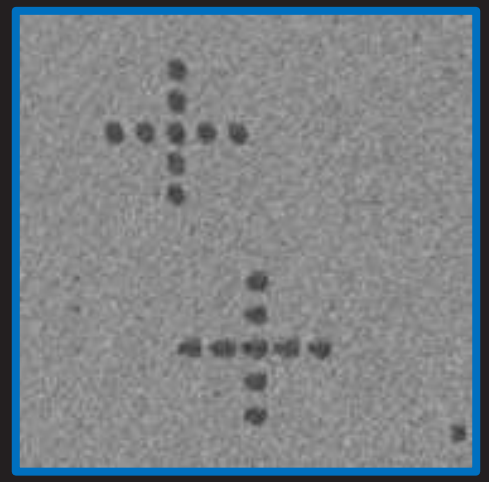
Summary

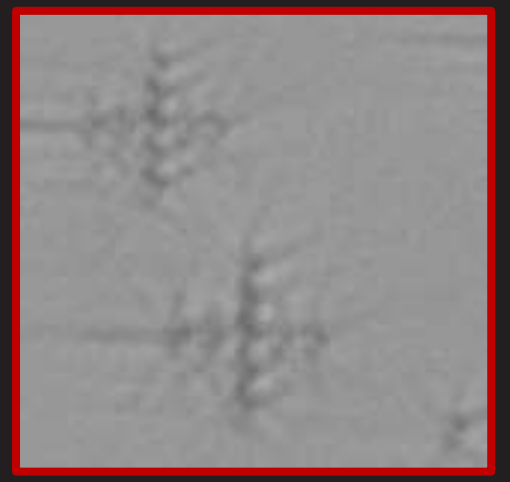
Data quality in X-ray CT can vary substantially between instruments or laboratories:

- Most likely cause of poor data is either:
  - Poor instrument service
  - Poorly controlled laboratory environment
- IQI can be used to visually evaluate the reconstructed image quality
- Signal processing provides the most robust method of instrument resolution optimisation & measurement

7.5µm Features



NanoTOM – Waygate Technologies



NXCT – ZEISS VERSA620