BALANCING NOISE REDUCTION WITH SPATIAL RESOLUTION IN CLINICAL CT

Julian Liu
Henry Weatherburn
Aspen Healthcare
Andrew Wainwright
Buckinghamshire NHS Healthcare

Origin of Noise

- Thermal noise during acquisition
- Discrete X-ray events
- Poisson distribution
- Partial volume
- Computational errors (e.g. The filtering of FBP)
- Artificial scanning object (non-biologocal)

Factors Affecting Spatial Resolution

- Kernel functions
- Field of view
- Reconstruction
- The number of views in a scanning circle
- Detector dimensions

Analysis of the Factors

Kernel functions

- Different level of smoothness and sharpness
- Gaussian smoothing
- Fourier transform

Field of the view

- Directly limiting the spatial resolution
- Interpolating the projected views to increase spatial resolution
- High resolution using opposite projection as a view

Analysis of the Factors

Reconstruction

- FBP sensitive to noise
- Iterative robust to noise but with high computational load

Numbers of the views

- Direct contribution to spatial resolution
- Noise related (Poisson distribution)

Detector dimensions

- Thermal noise and Poisson distribution
- Low temperature technique (Manufacturers)

Noise Detection & Isolation – Method Developed for Noise Reduction

Noise mixed with image details

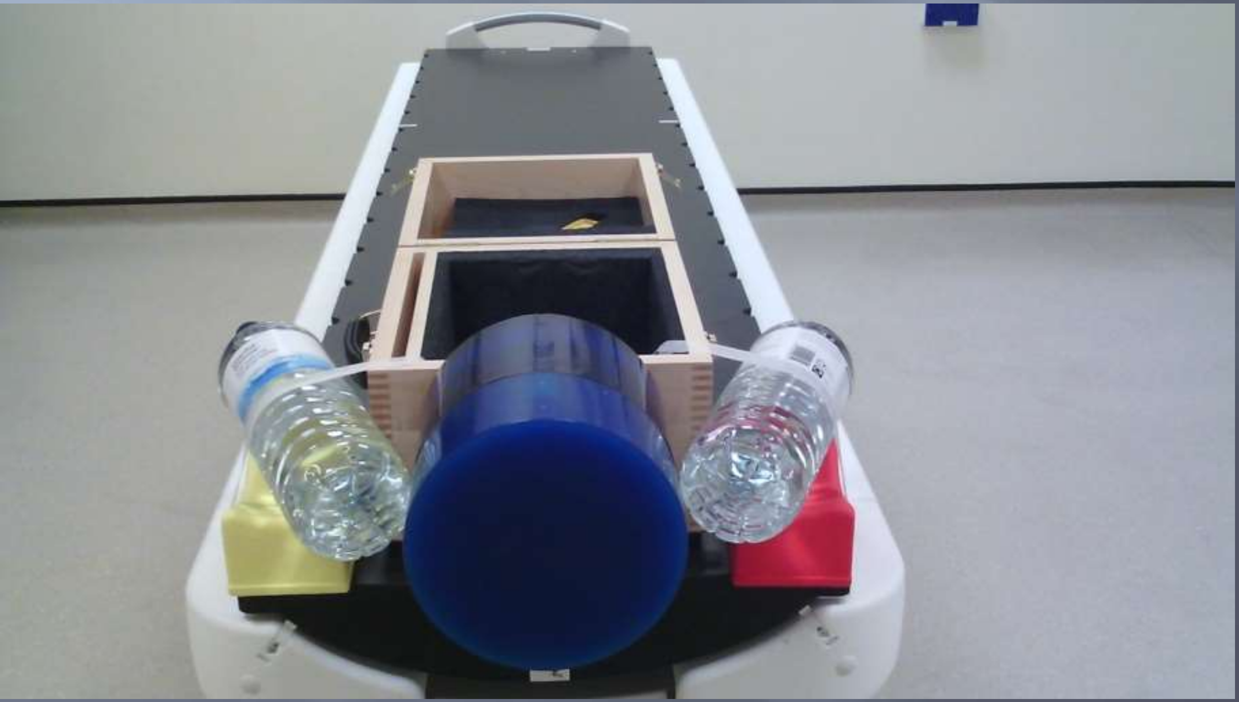
- Smoothing removes some noise as well as useful imaging details
- Sharpening amplifies both imaging details and noise

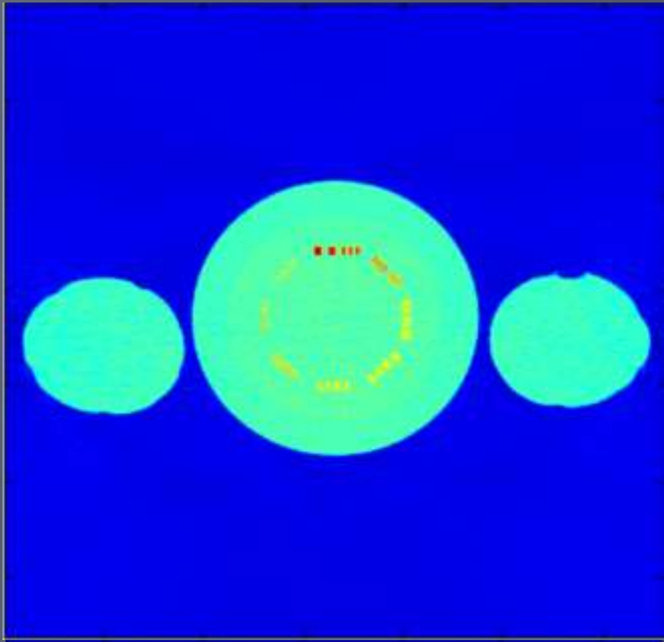
Experiment Design

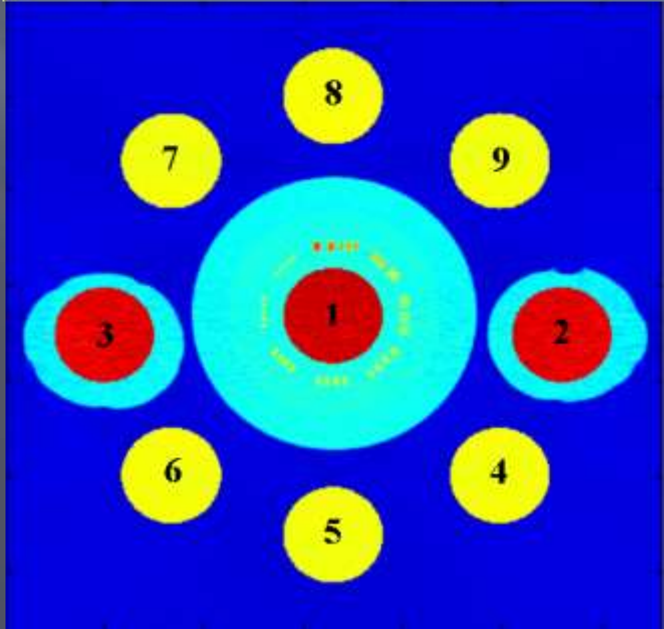
- Scanning Object: Catphan700 CTP714 + two 2L water bottle on each side
- Siemens Somatom Definition AS 64
- 23 scans using ThorHRSeq: 70-140 kV, 20-300 mAs, 2 x 1 mm
- Noise reduction prior to reconstruction
- 9 ROIs
- Full and half circle

Experiment Design

23 Scans				kV/mAs/CTDIvol _mGy
1. Care 120/123/7.4		10. 100/300/12.7	15. 80/300/6.5	20. 70/300/4.0
2. 140/150/15.6	6. 120/200/14.6	11. 100/200/8.5	16. 80/200/4.3	21. 70/200/2.7
3. 140/100/10.4	7. 120/100/7.2	12. 100/100/4.2	17. 80/100/2.2	22. 70/100/1.3
4. 140/50/5.2	8. 120/50/3.6	13. 100/50/2.1	18. 80/50/1.1	23. 70/60/0.8
5. 140/20/2.0	9.120/20/1.3	14. 100/20/0.8	19. 80/20/0.4	





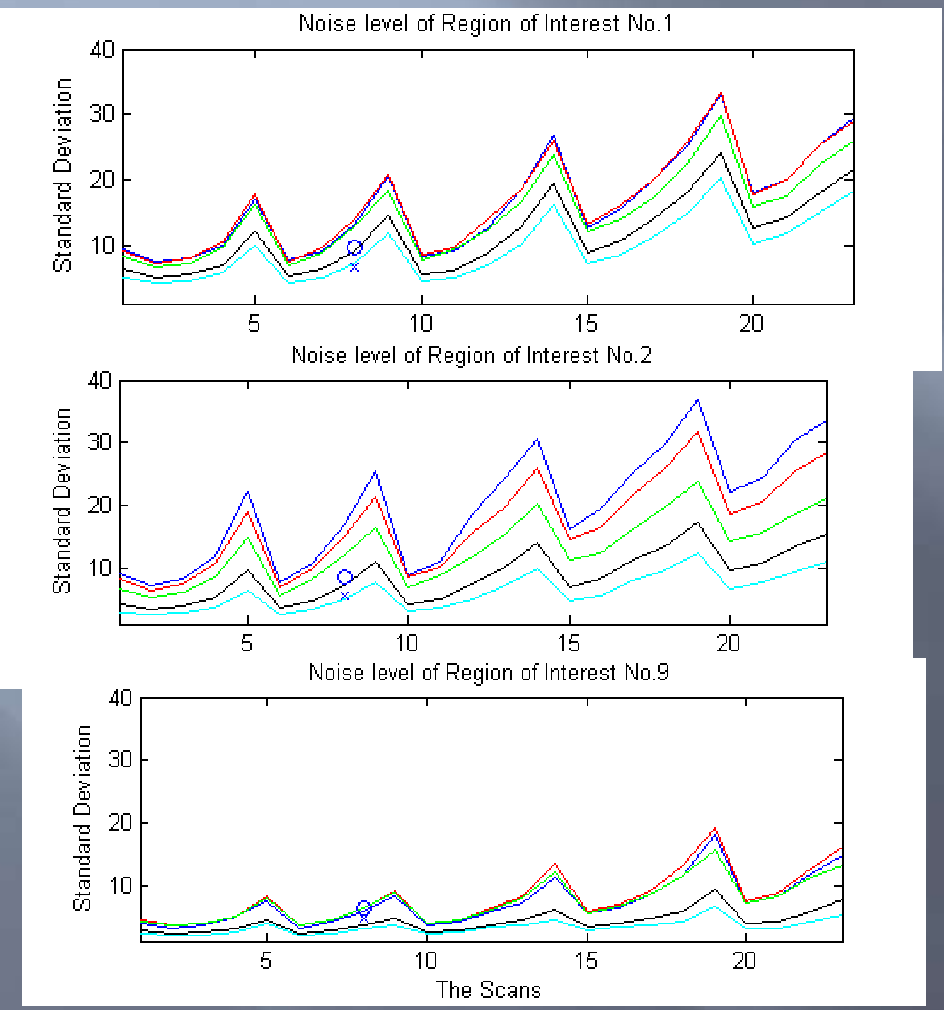


Noise Reduction Prior to Reconstruction

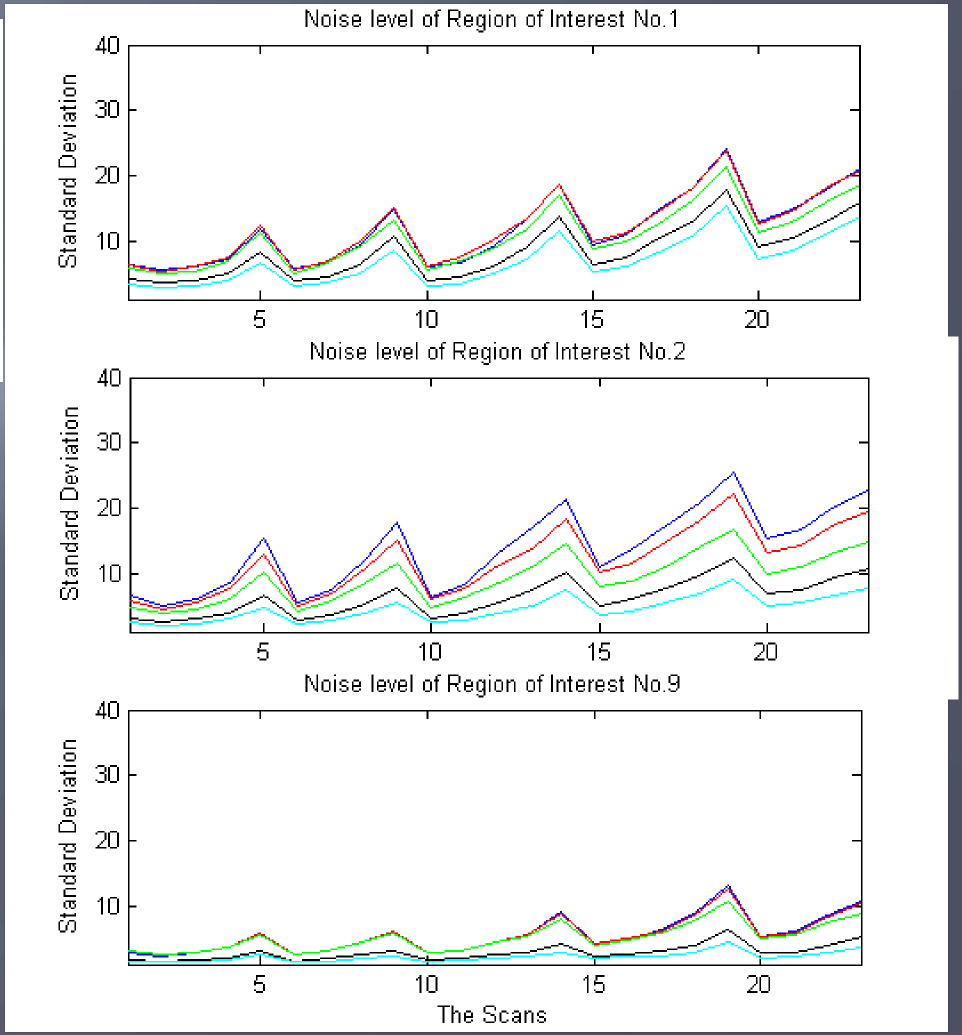
Noise reduction

- Threshold of 0.25 maximum in high frequency component
- Threshold of 0.25 maximum in high frequency component removing twice
- Full high frequency component removing
- Full high frequency component removing twice

Noise Levels

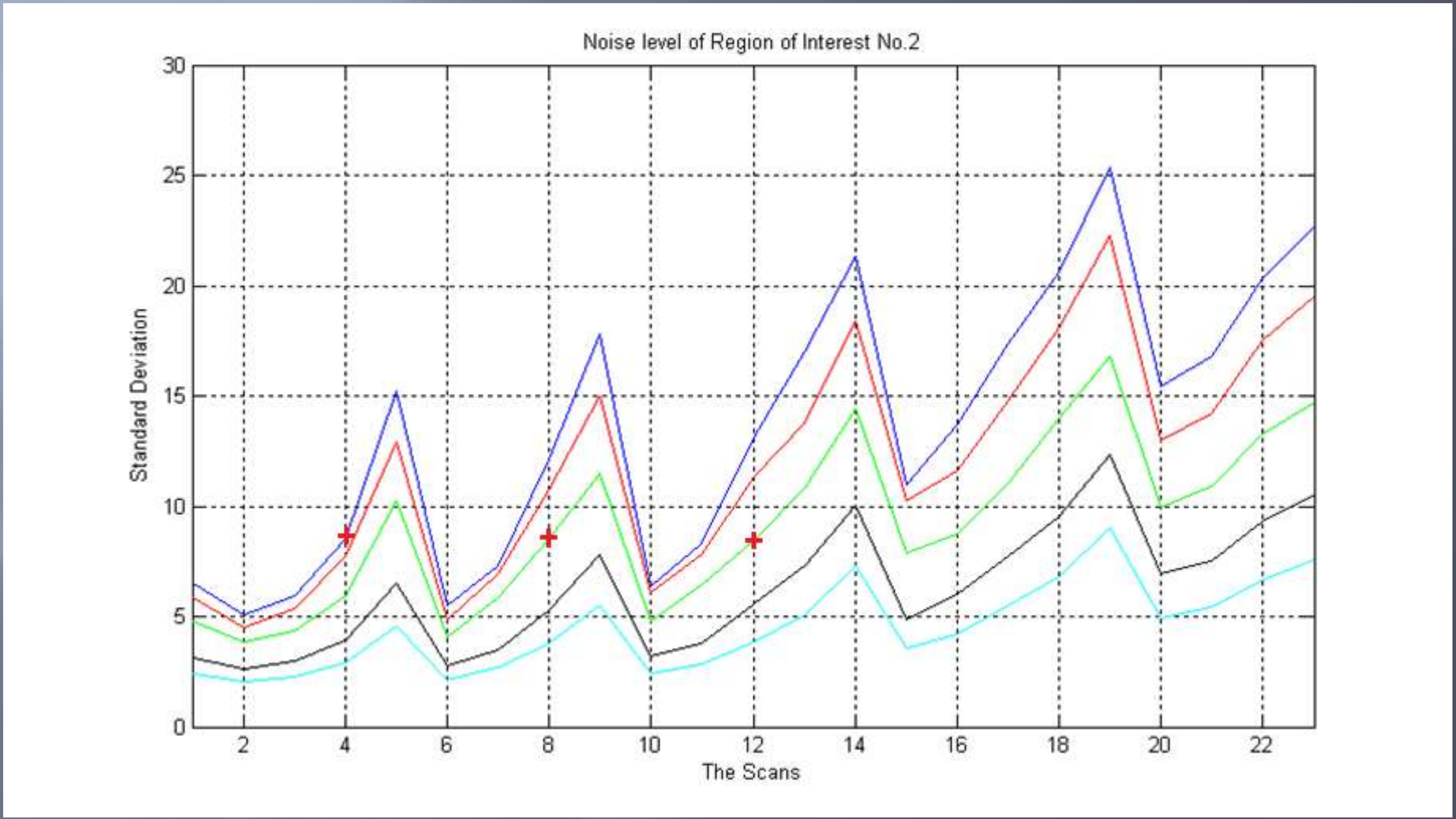


Half Circle



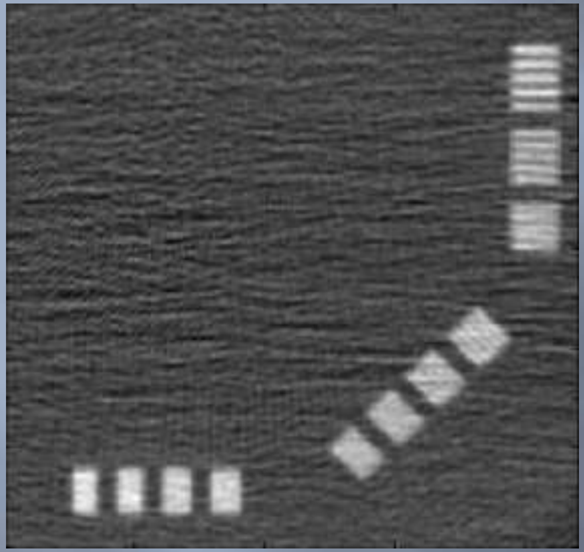
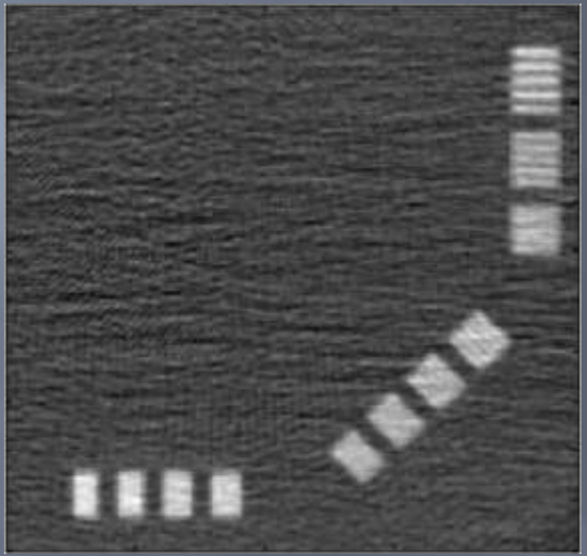
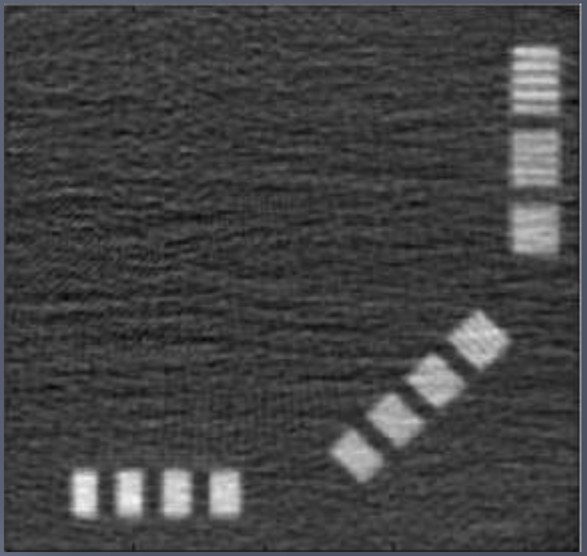
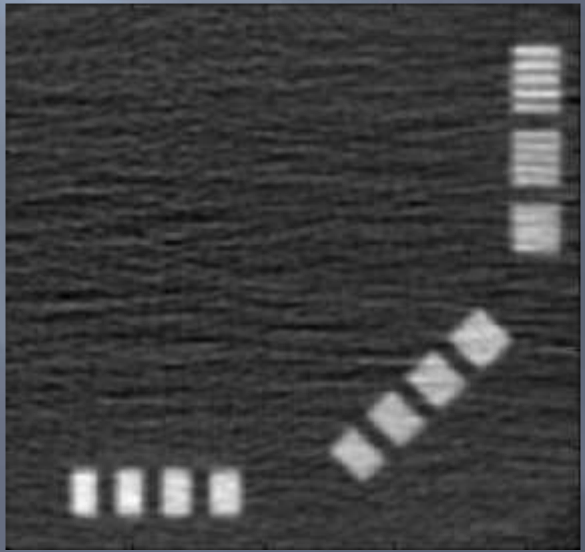
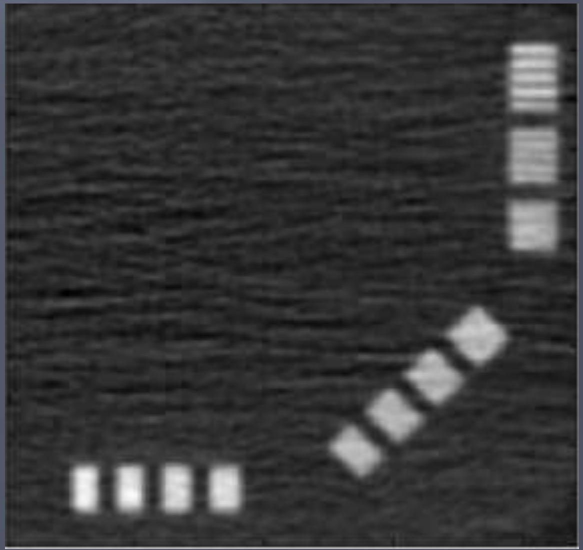
Full Circle

Noise Levels of ROI No.2



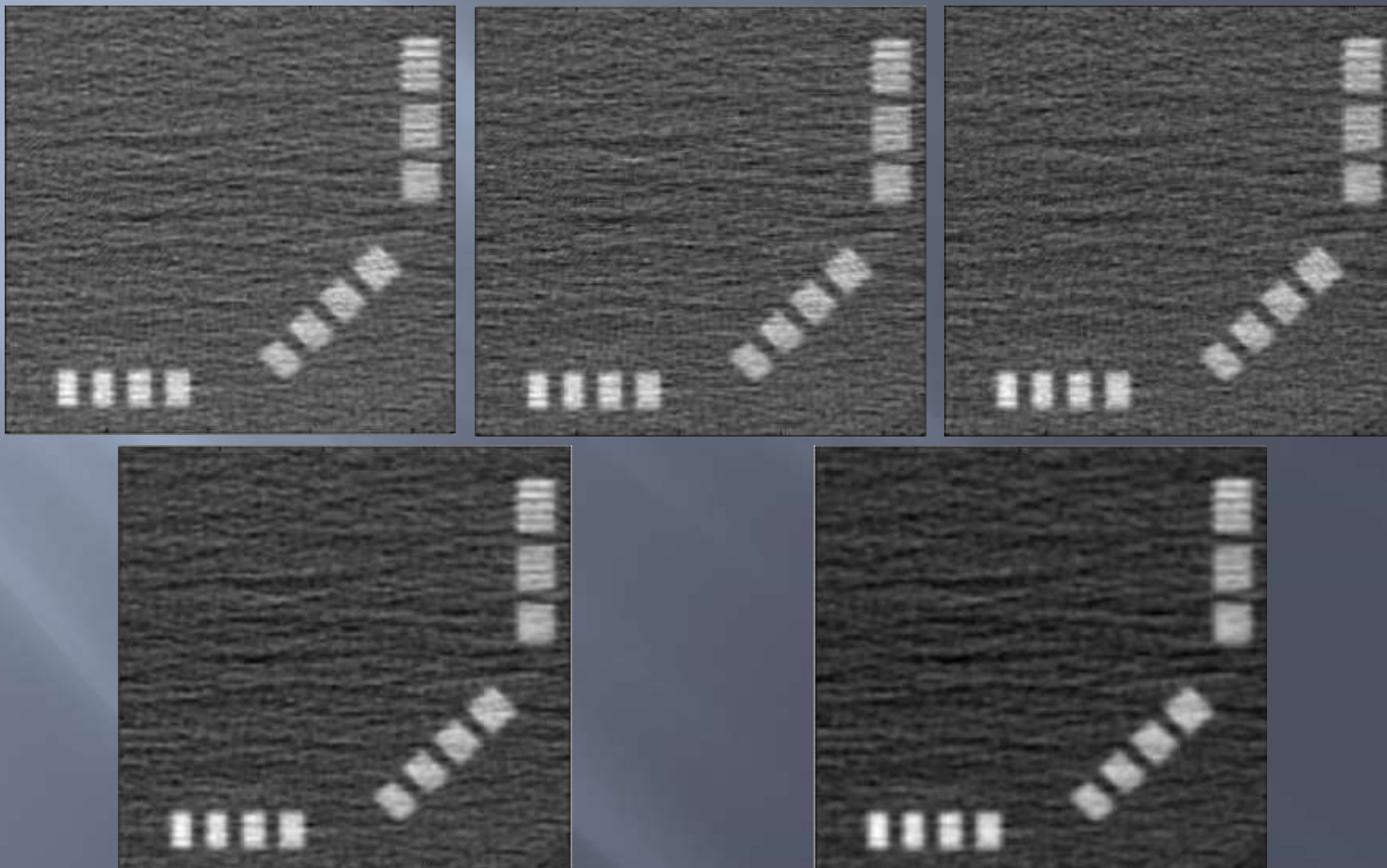
Spatial Resolution

- 140kV, 150 mAs, 15.6 mGy/cm

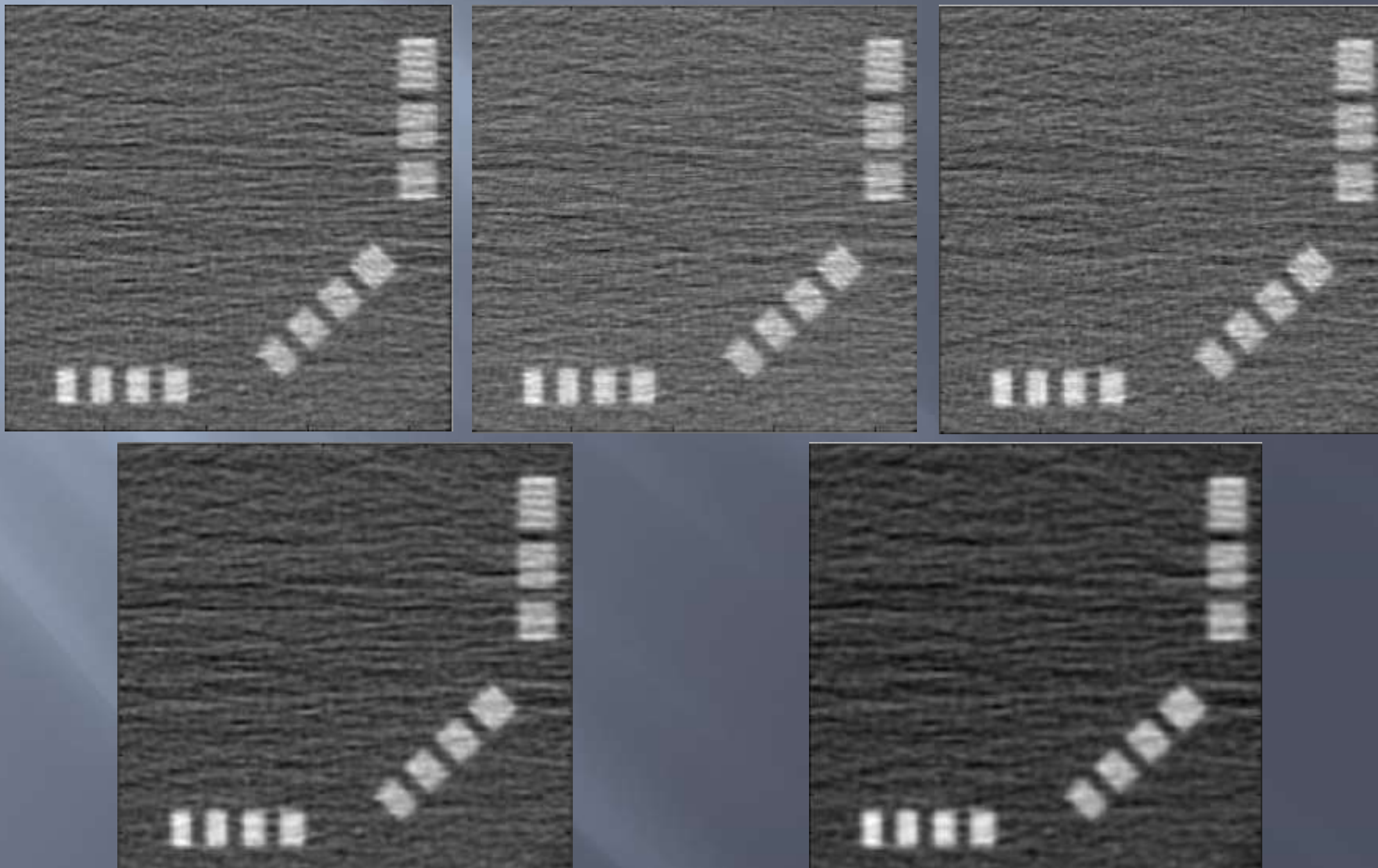
Spatial Resolution

- 140kV, 50 mAs, 5.2 mGy/cm



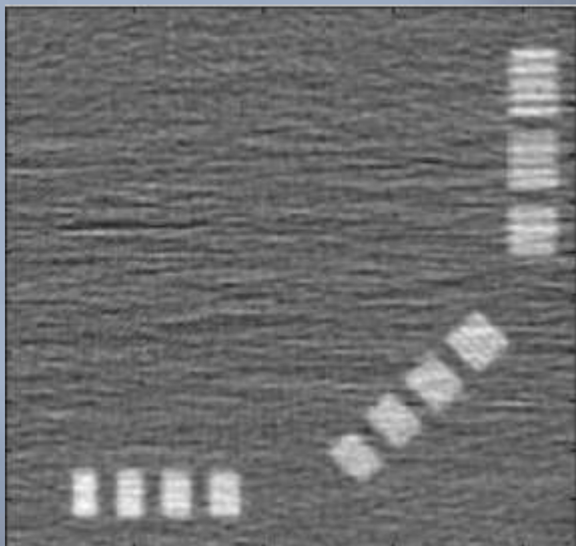
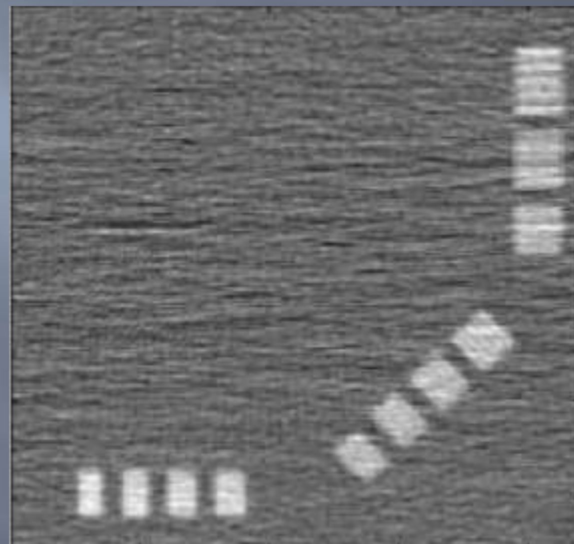
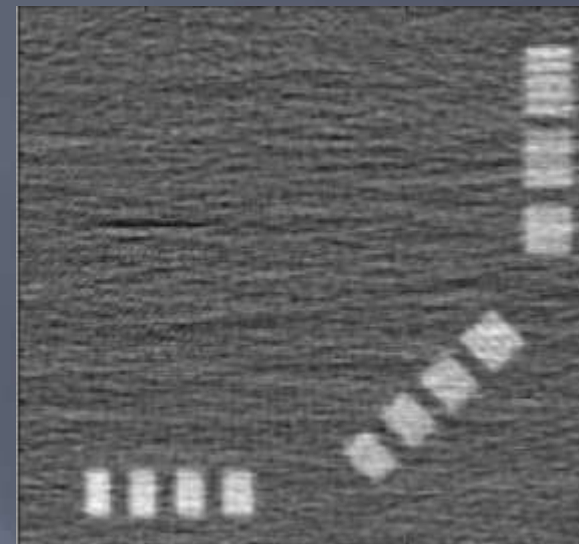
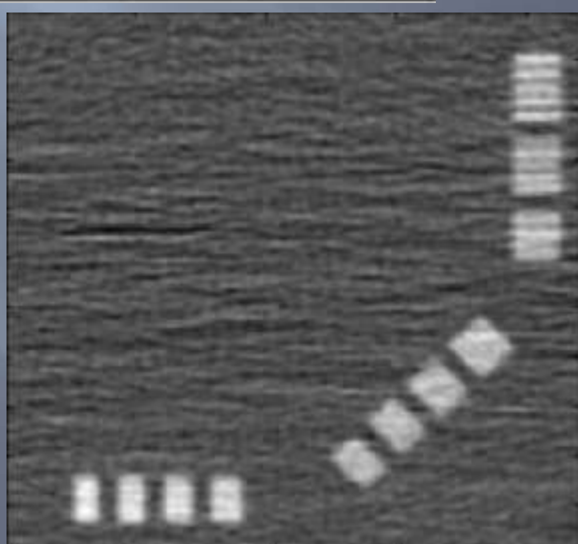
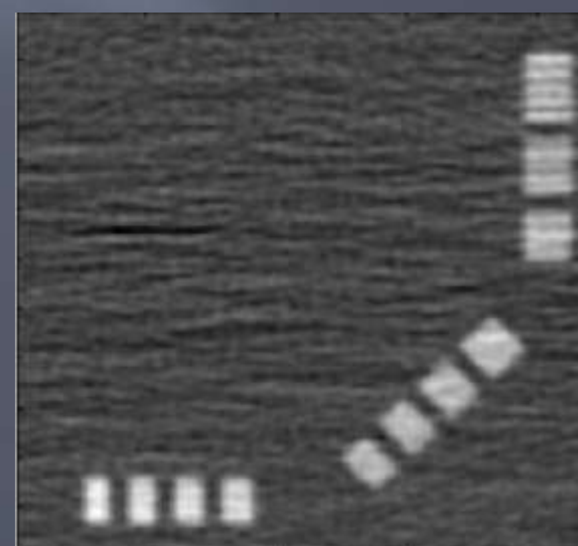
Spatial Resolution

- 120kV, 50 mAs, 3.6 mGy/cm



Spatial Resolution

- 100kV, 100 mAs, 4.2 mGy/cm

Conclusions and Discussions

- The noise detection method with a suitable threshold can reduce the false positives
- A few iterative applications of the method can be effective
- The computational load less than 1 second per slice
- A loss resolution recovery is applicable if computationally allowed

Acknowledgement

The authors appreciate the help from George Wallis, a medical physics MSc student from Guilford University