

Noise and dose reduction for Lung/Shoulder CT scan

Julian Liu

Clinton Green

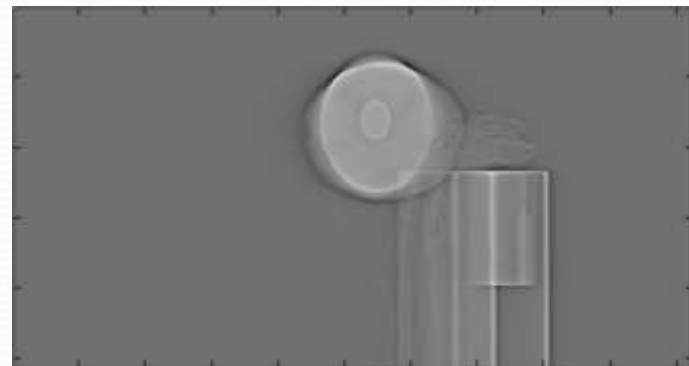
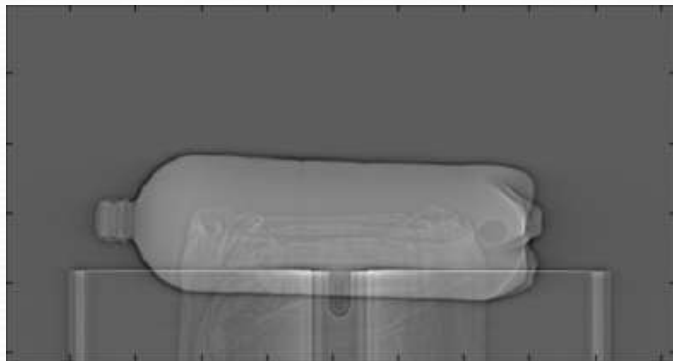
Andrew Wainwright

Buckinghamshire Healthcare NHS Trust

The problems

- Siemens Somatom Definition AS 64
- Caredose and CarekV
- Topogram tube top/lateral

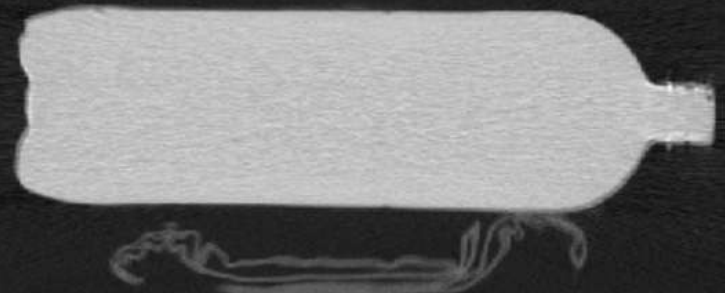
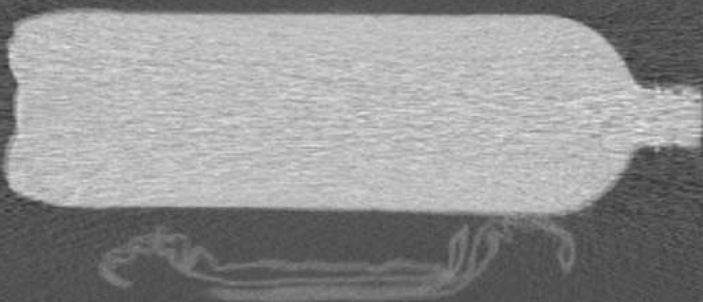
Topogram	Caredose	CarekV	kV	mAs	Ref	CTDI
Top	On	On	80	33	507	0.6L
Lateral	On	On	100	87	180	3.36L



The problems

- The difference in image quality/noise level
- If the image quality improvable
- The spatial resolution

Topogram	Caredose	CarekV	kV	mAs	Ref	CTDI
Top	On	On	80	33	507	0.6L
Lateral	On	On	100	87	180	3.36L



Methods

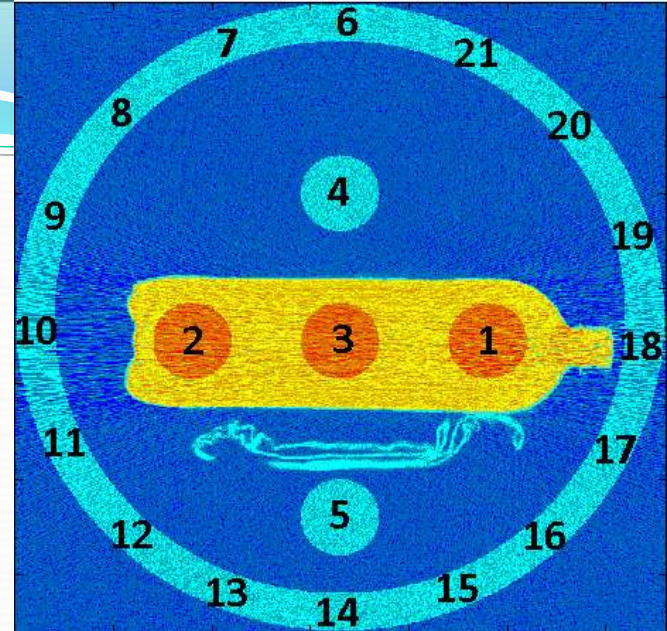
Noise detection and isolation

- Convoluting the projection with Haar base functions
- Using the views with lower level of noise to set up threshold in the highest frequency component
- Removing the detected noise in the highest frequency component
- Reconstructing the projection using the amended highest frequency component

Experiments

- Siemens AS 64
- A 2L drink bottle
- Sequential (axial) scanning protocols making the analysis more reliable
- Lower dose or lowest dose parameters comparing to the Caredose/kV selections

Experiments



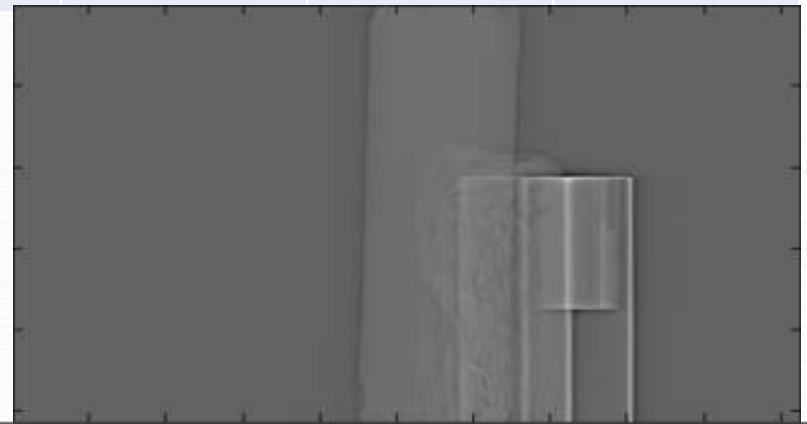
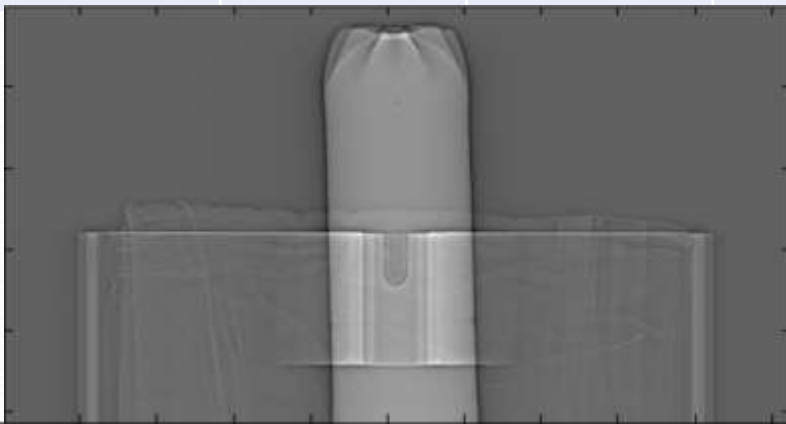
Mask for regions of interest

- ROIs of water in central area (1-3)
- ROIs of air in central area (4,5)
- ROIs of air in peripheral area (6-21)

Experiments

HRCT, 1mm x 2, Phantom axis in Z direction

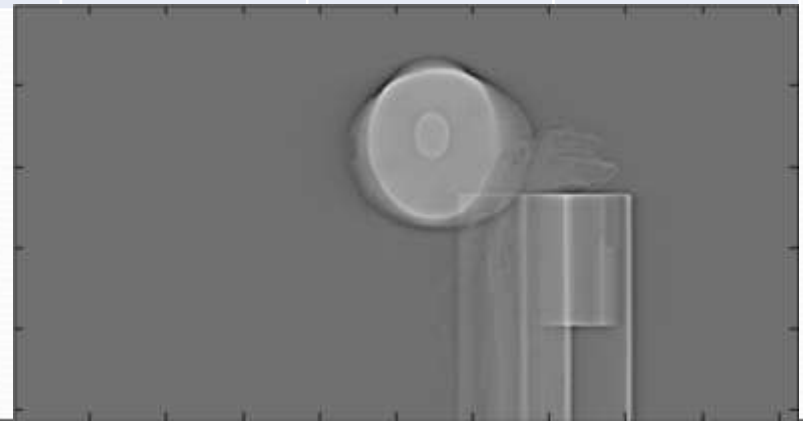
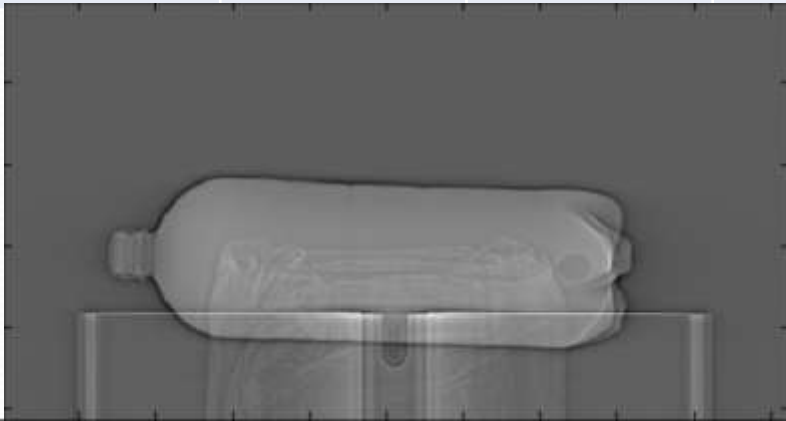
Topogram	Caredose	CarekV	kV	mAs	Ref	CTDI
Top	On	Off	120	20	110	1.26L
Lateral	On	Off	120	20	110	1.26L
Top	On	On	80	33	507	0.6L
Lateral	On	On	80	28	507	0.52L
Top	Off	Off	120	110	Reference	7.21L
Top	Off	Off	80	20	Lowest	0.35L



Experiments

HRCT, 1mm x 2, Phantom axis in X direction

Topogram	Caredose	CarekV	kV	mAs	Ref	CTDI
Top	On	Off	120	20	110	1.26L
Lateral	On	Off	120	57	110	3.83L
Top	On	On	80	33	507	0.6L
Lateral	On	On	100	87	180	3.36L
Lateral	Off	Off	120	110	Reference	7.21L
Lateral	Off	Off	100	20	Lowest	0.74L



Experiments

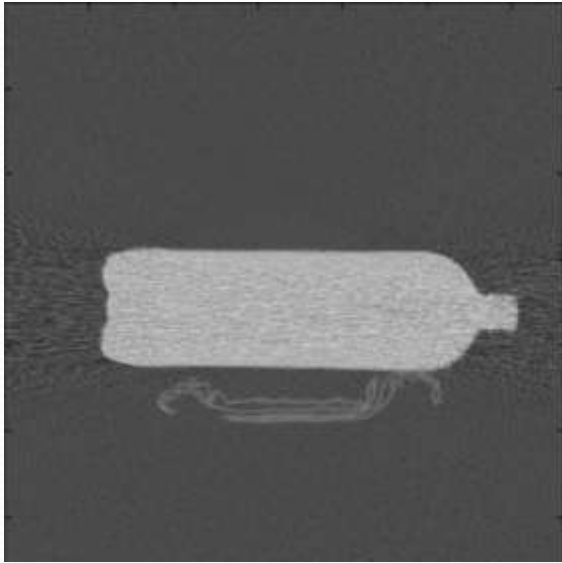
Applying noise reduction to the scans with the parameters as follows

kV	mAs	CTDI
80	33	0.6L
80	20	0.35L

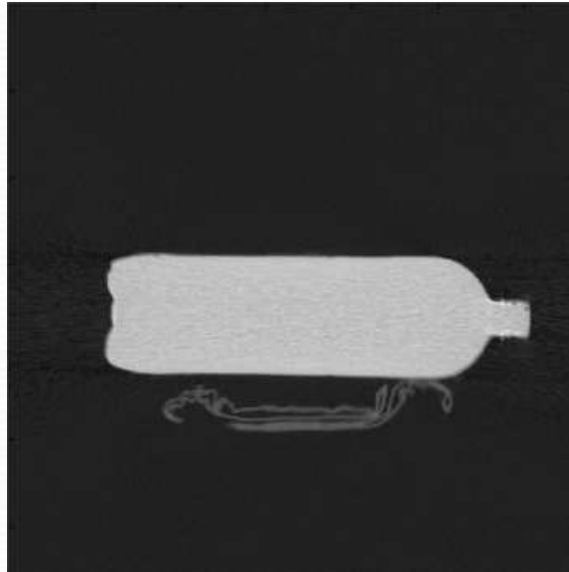
Comparison with

kV	mAs	CTDI
120	110	7.21L
120	20	1.26L
100	87	3.36L
100	20	0.74L

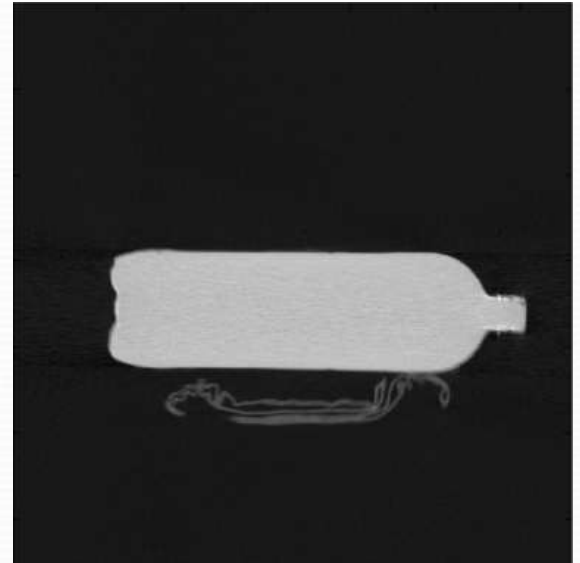
Results



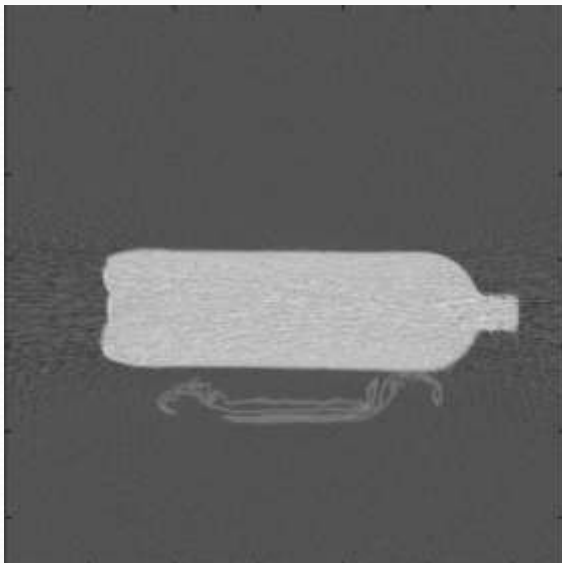
80 kV 33 mAs



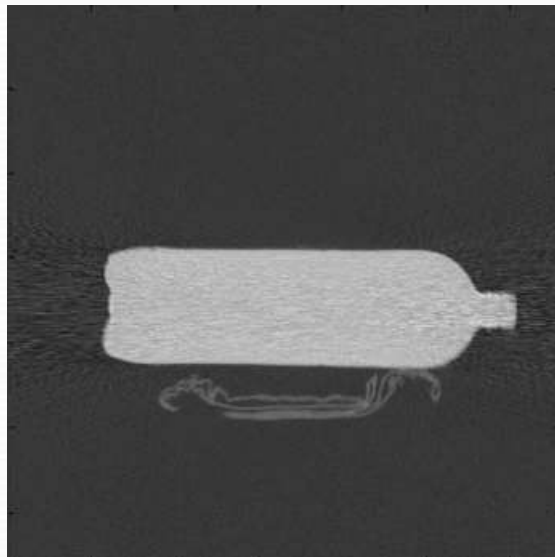
100 kV 87 mAs



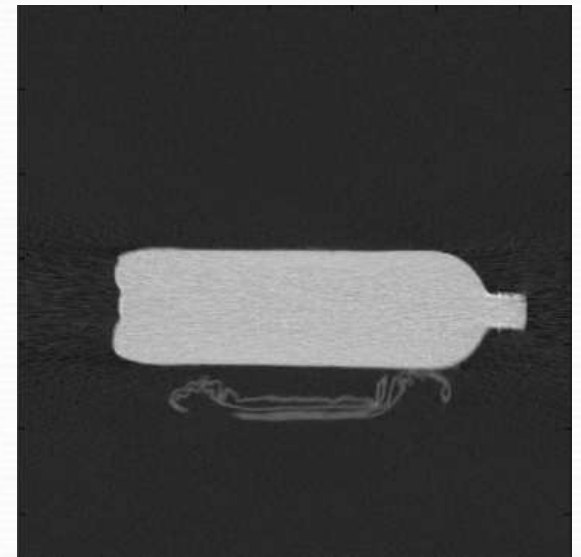
120 kV 110 mAs



80 kV 20 mAs

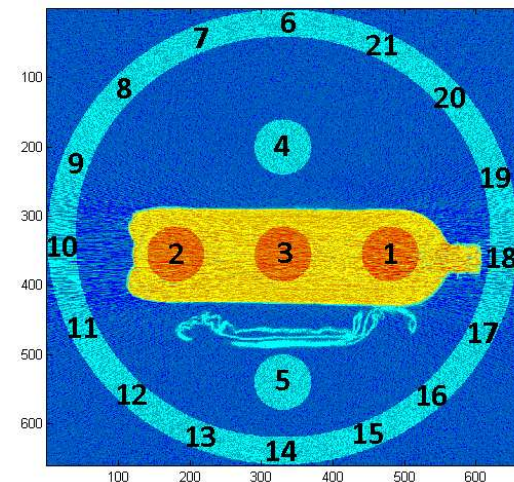


100 kV 20 mAs

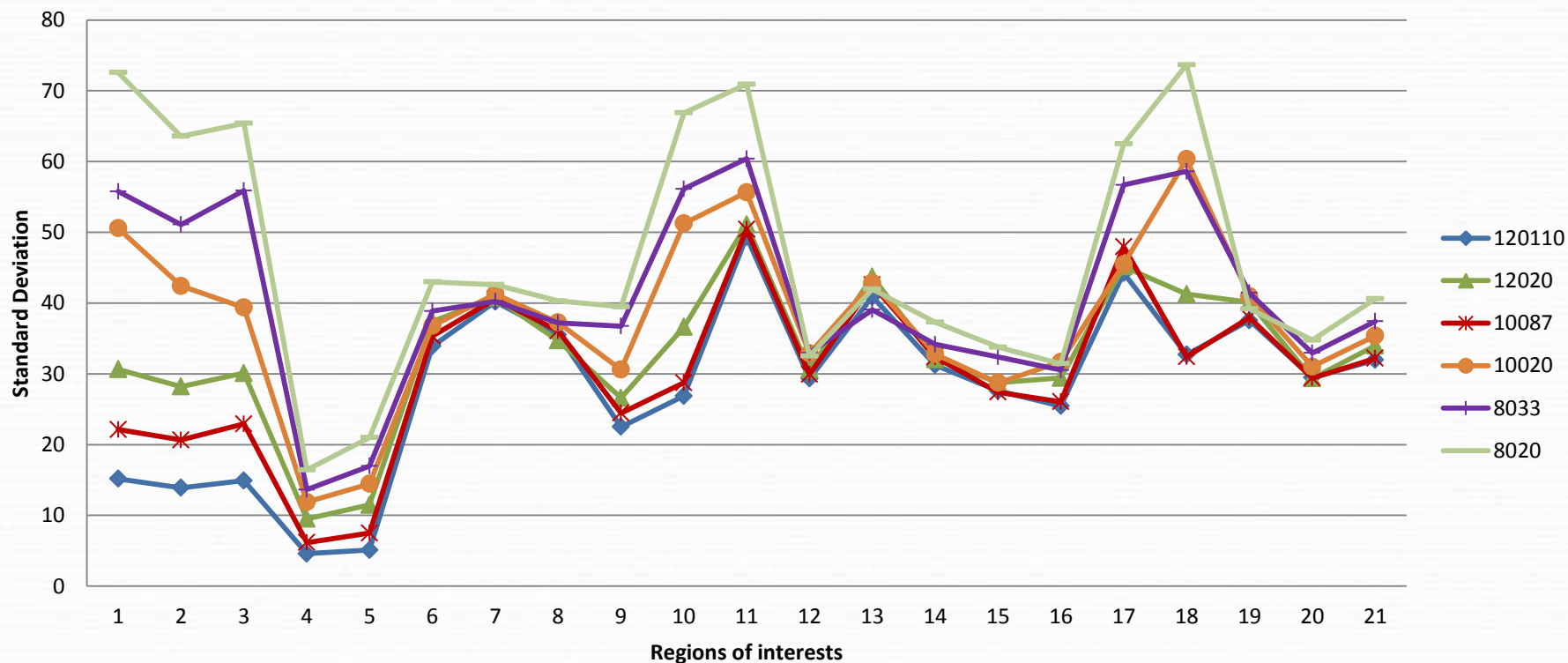


120 kV 20 mAs

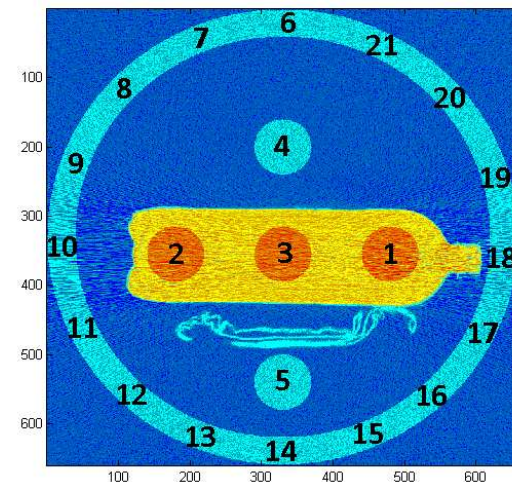
Results



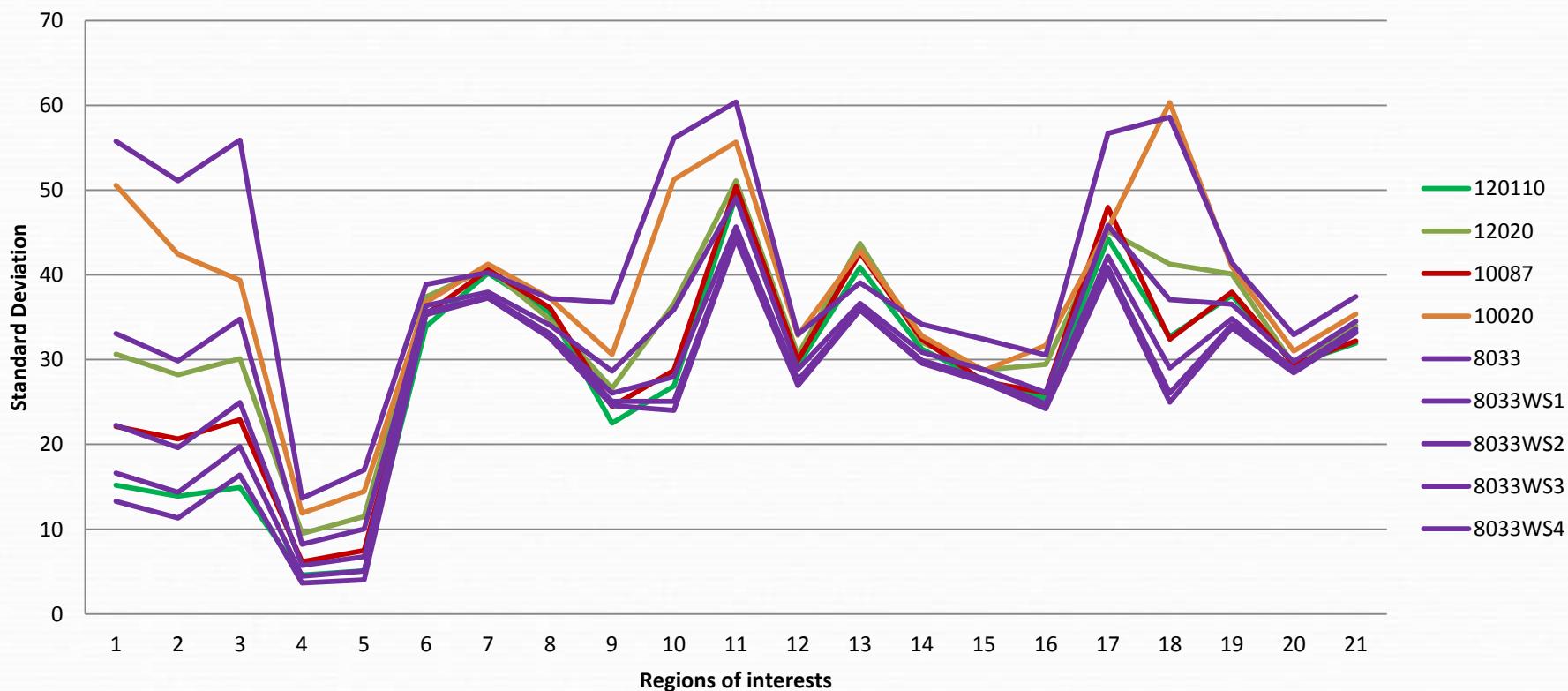
The noise levels in the regions of interest



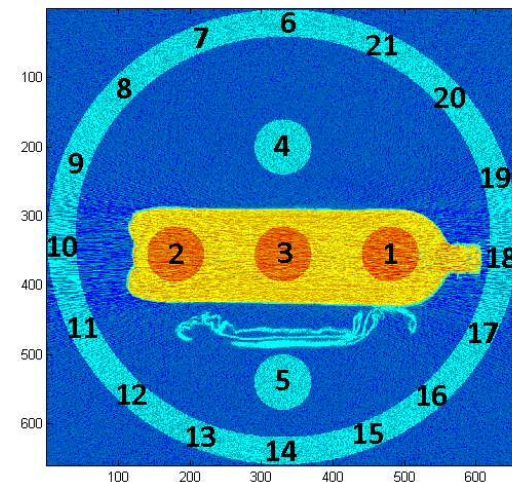
Results



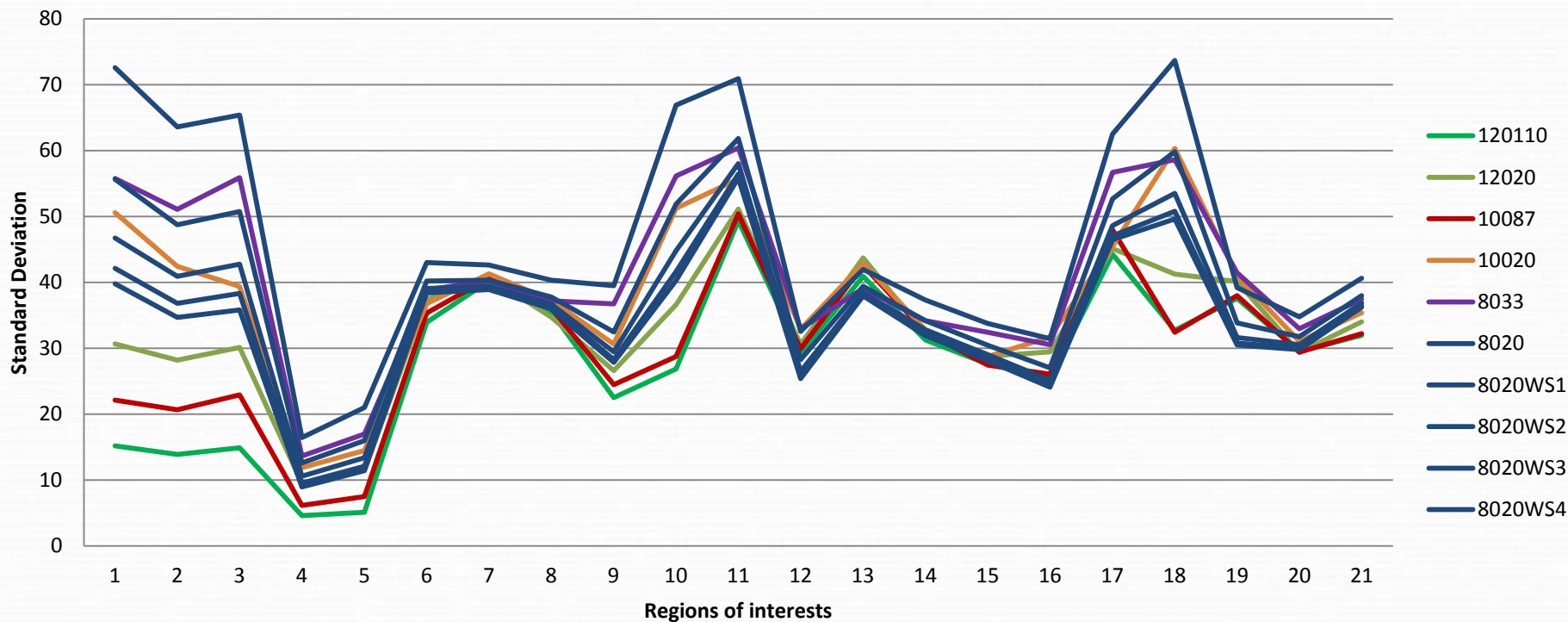
The noise levels in the regions of interest



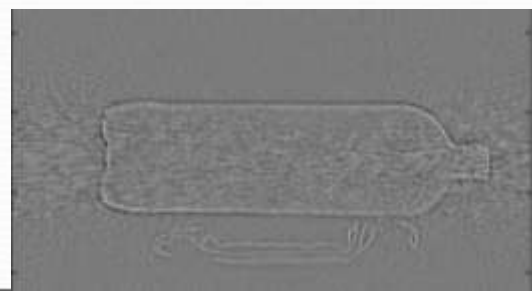
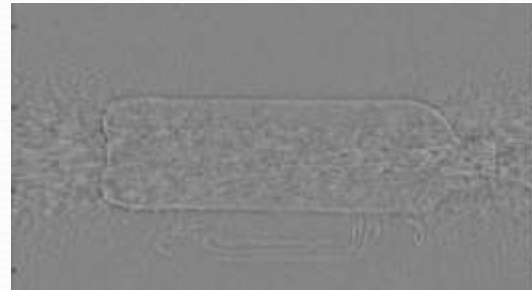
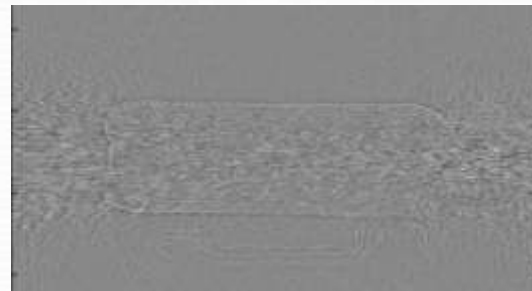
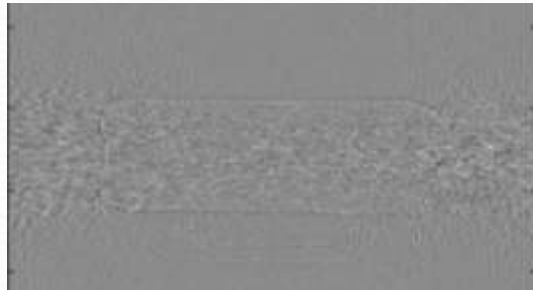
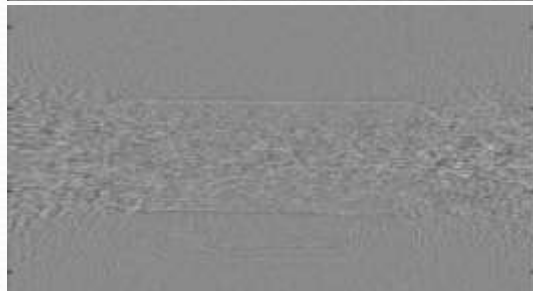
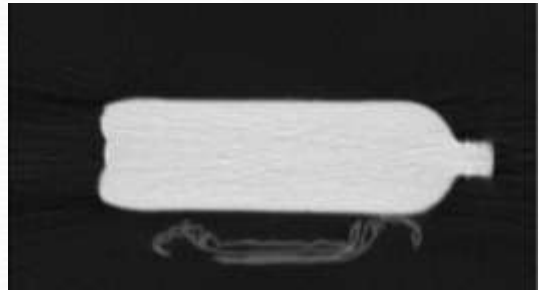
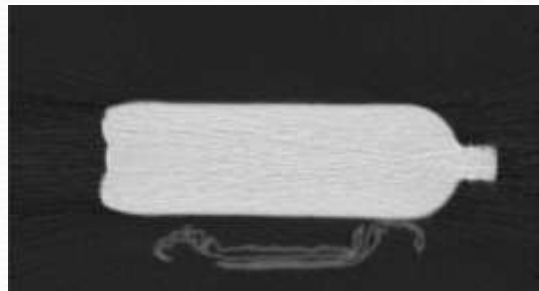
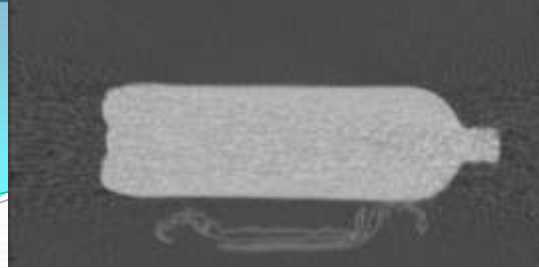
Results



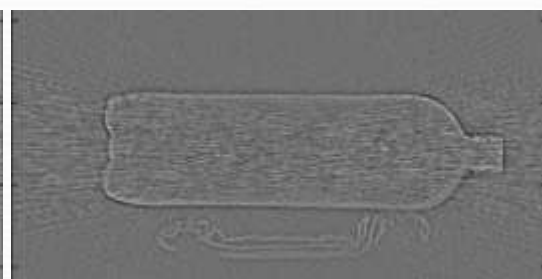
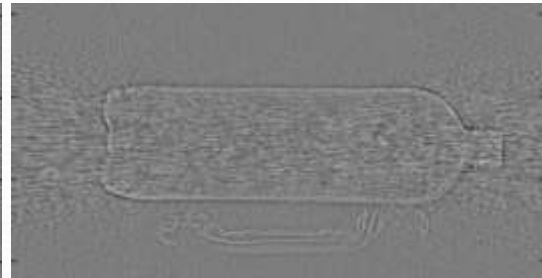
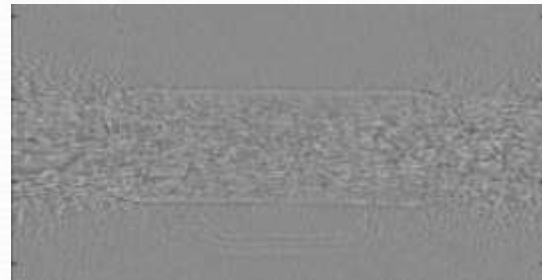
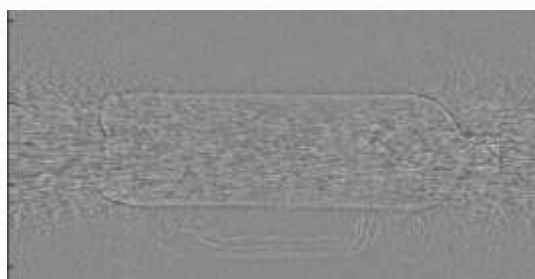
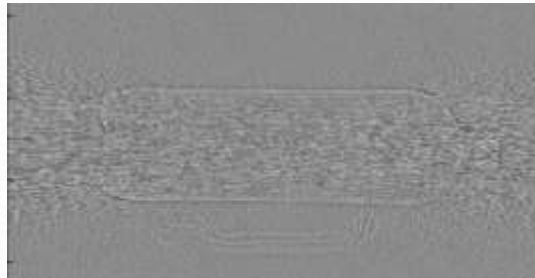
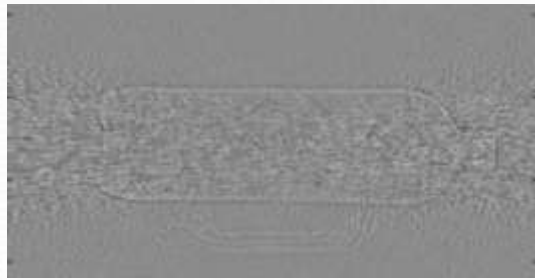
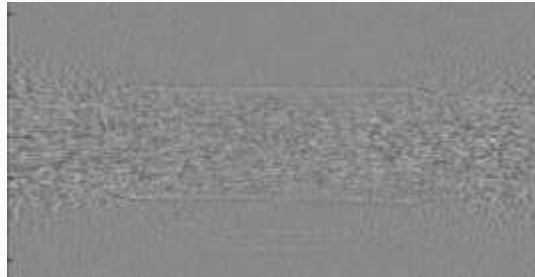
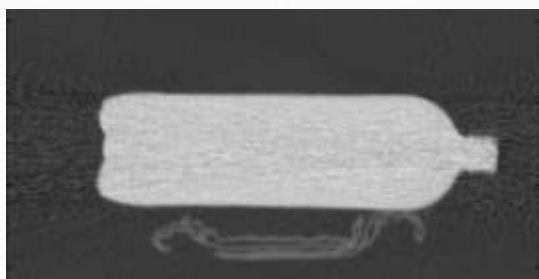
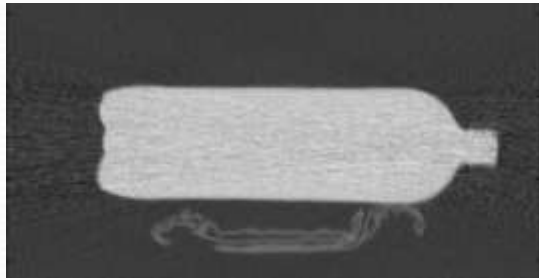
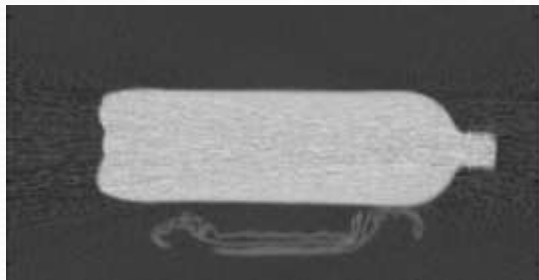
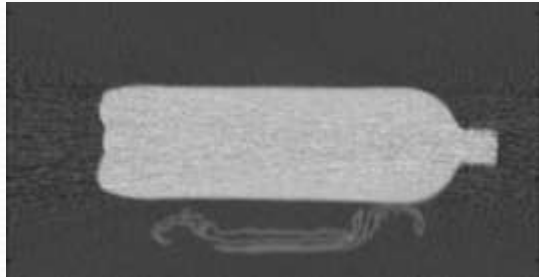
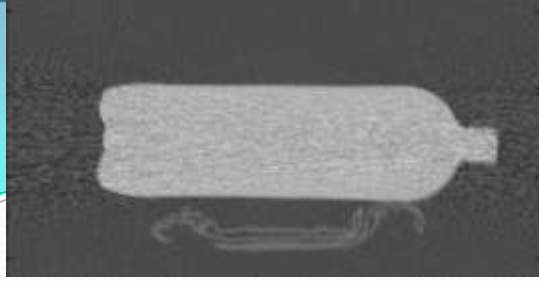
The noise levels in the regions of interest



Results-Resolution of 33 mAs



Results-Resolution of 20 mAs



Discussion

Factors for noise reduction

- The percentage of noise level reduction
- The level of misclassification
- The computational load

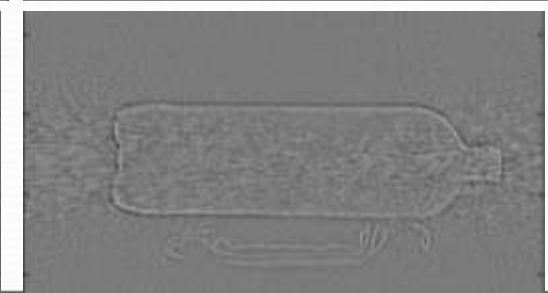
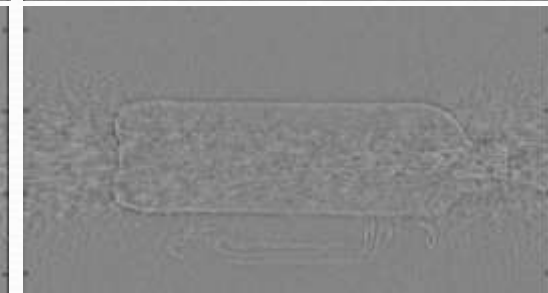
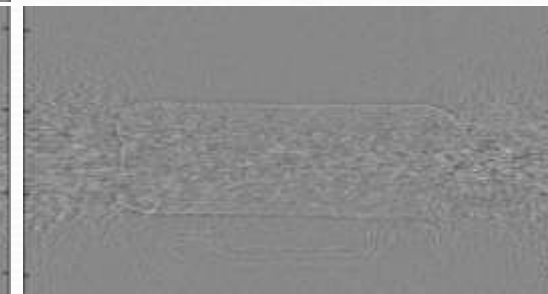
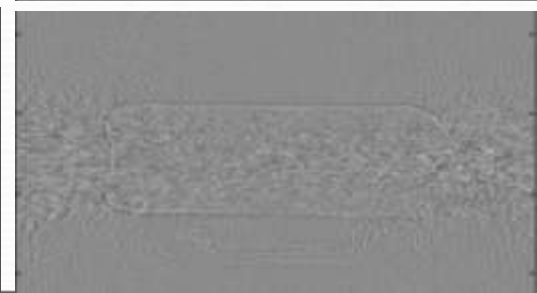
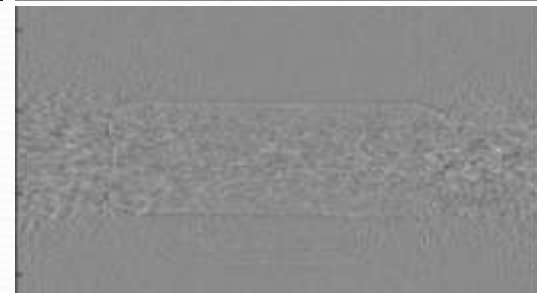
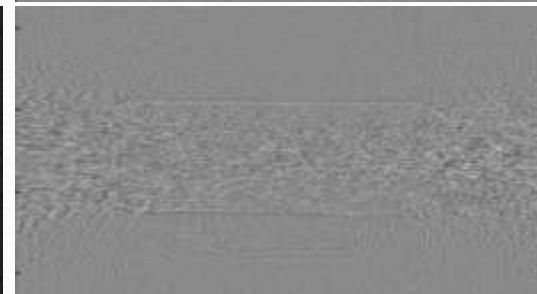
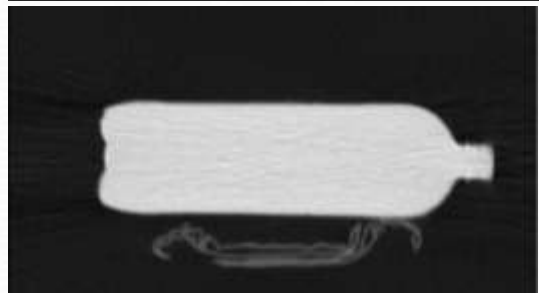
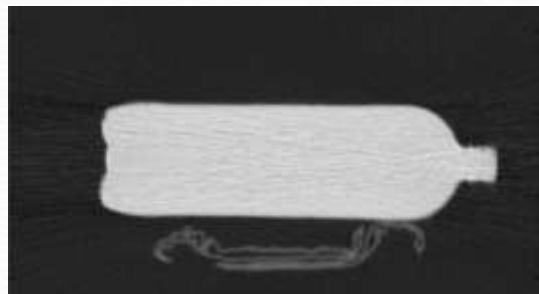
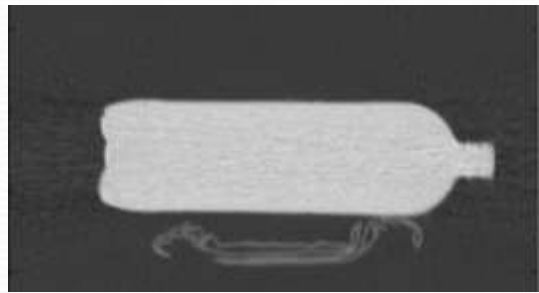
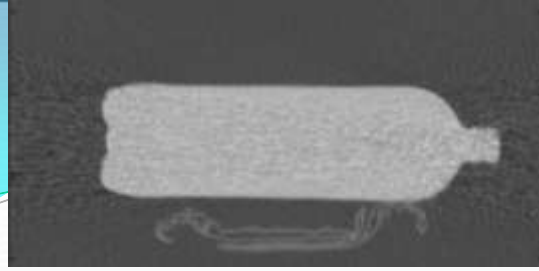
Ideally 100% noise reduction and zero misclassification but limited by the accuracy of the noise description

Balancing the factors

Conclusions

Original	No. repeat	NL similar to	Dose reduction	Resolution lost	Noise level
80 kV 33 mAs	1	120 kV 20 mAs	52.38%	hardly	acceptable
80 kV 20 mAs	1	80 kV 33 mAs	41.67%	hardly	average
80 kV 33 mAs	2	100 kV 87 mAs	82.14%	Not significant	good
80 kV 20 mAs	2	100 kV 20 mAs	72.22%	Not significant	acceptable

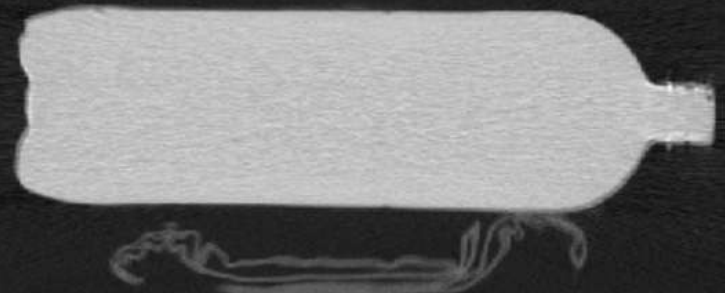
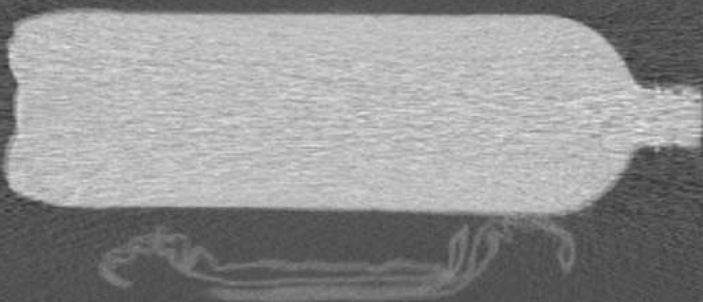
Results-Resolution of 33 mAs



Conclusions

- The noise level of 80 kV, 33 mAs + noise reduction x 2 = the noise level of 100 kV, 87 mAs
- With acceptable spatial resolution lost

Topogram	Caredose	CarekV	kV	mAs	Ref	CTDI
Top	On	On	80	33	507	0.6L
Lat	On	On	100	87	180	3.36L



Conclusions

Computational features

For noise reduction, each slice taking less than 0.5 second using MATLAB on a Dell Laptop Intel(R) Core(TM) i7 CPU Q720 @ 1.60 GHz 1.60 GHz (3 year old)

Work in the future

The lost resolution could be retrievable with acceptable computational load