University Hospitals Plymouth NHS Trust

Intra-Scanner Detector and AEC Study

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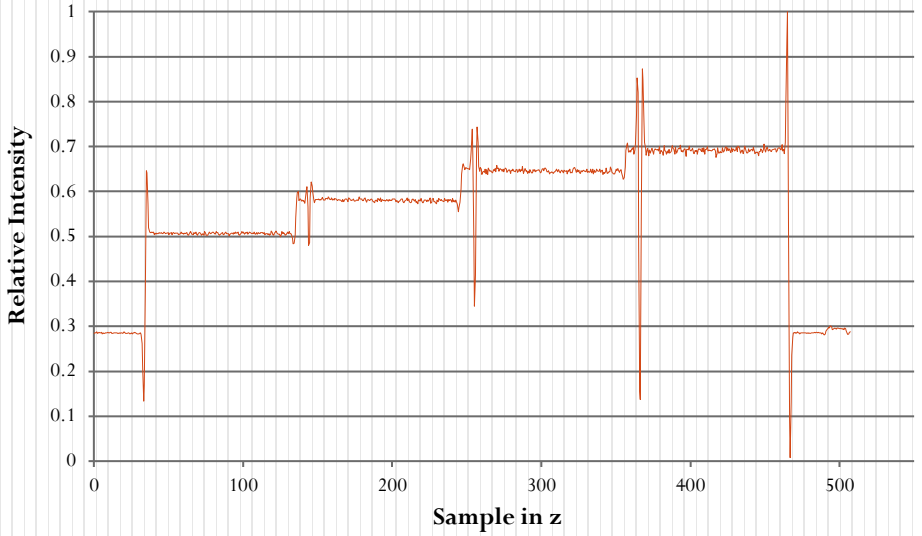
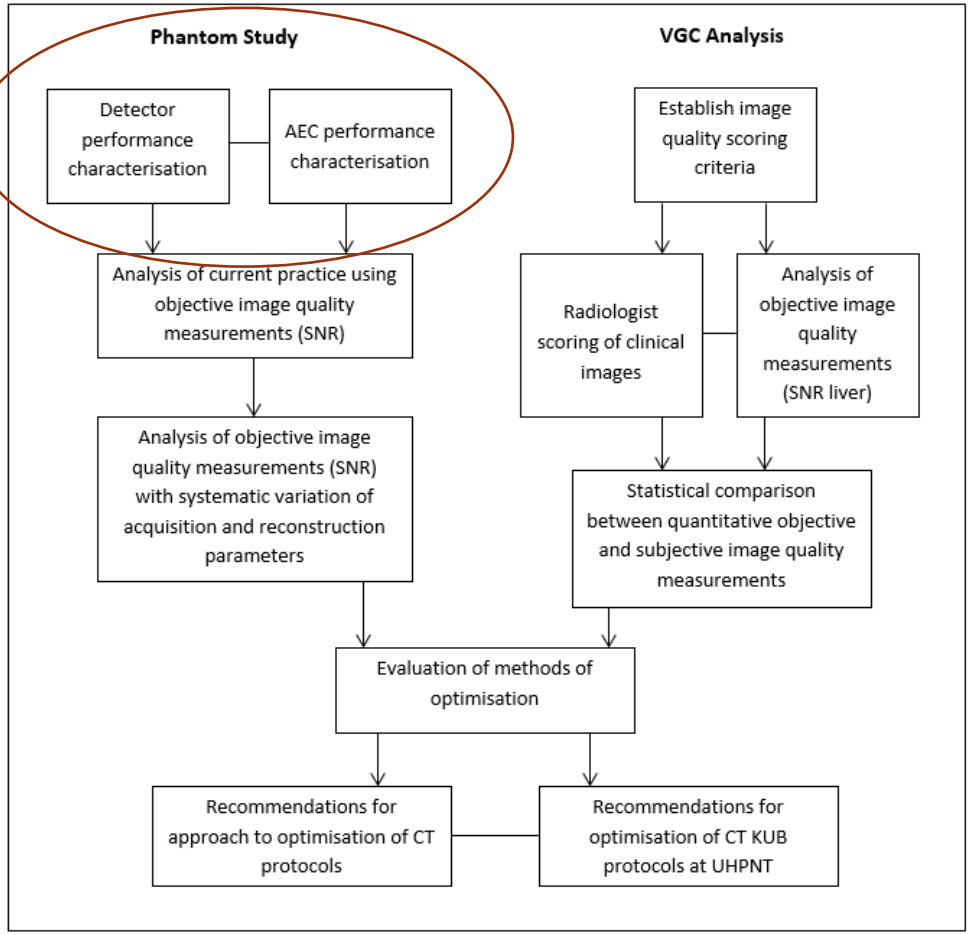


Study Aim

To characterise the detector and Automatic Exposure Control (AEC) performance of each diagnostic CT scanner at UHPNT.

- Understand the baseline characteristics of each scanner in phantom study;
- Use the findings in order to inform recommendations for optimisation of CT protocols.
- Kidney Ureter Bladder (KUB) CT protocol.



GE Fleet at UHPNT

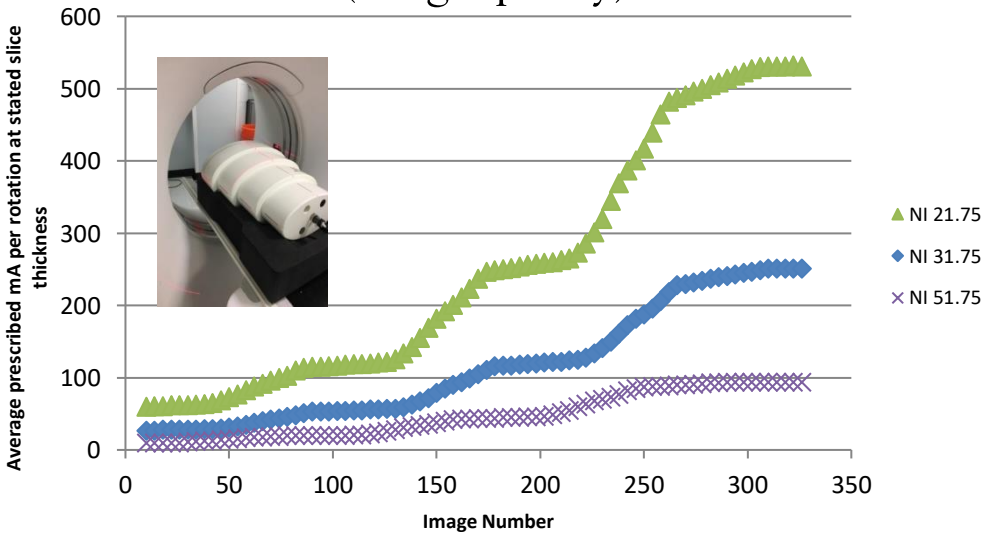
University Hospitals Plymouth NHS Trust

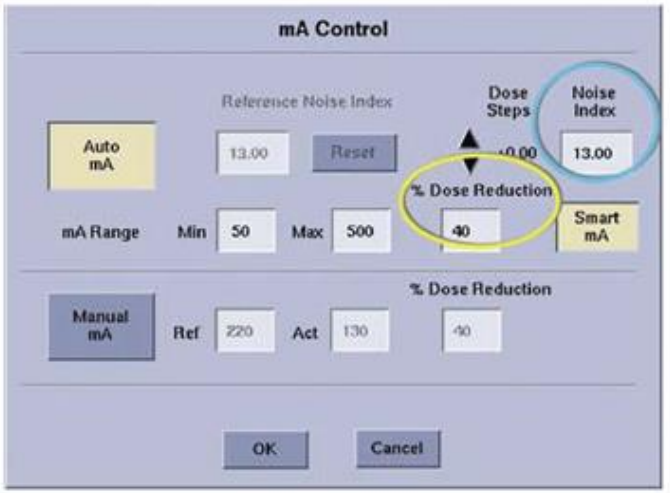
CT Scanner Name	Detector Configuration	Scanner Type	Detector Design
Optima 660 (West)	64 x 0.625	GE Optima 660	Scintillator - 64 detector rows (40mm)
HD750 Discovery (West)	64 x 0.625	GE HD750	Scintillator - 64 detector rows (40mm)
Optima 540 (East)	16 x 0.625	GE Optima 540	Scintillator - 16x 0.625mm + 4 x 1.25mm either side (20mm)
Lightspeed VCT (East)	64 x 0.625	GE Lightspeed VCT XT	Scintillator - 64 detector rows (40mm)
Optima 660 (West Room 17)	64 x 0.625	GE Optima 660	Scintillator - 64 detector rows (40mm)
Revolution CT (ED)*	256 x 0.625	GE Revolution CT	Scintillator - Wide coverage cone beam detector (160mm)
Discovery Revolution Evo (PET-CT)*	64 x 0.625	GE Discovery Revolution Evo	Scintillator - 64 detector rows (40mm)

*ASiR-V

GE Specific Parameters

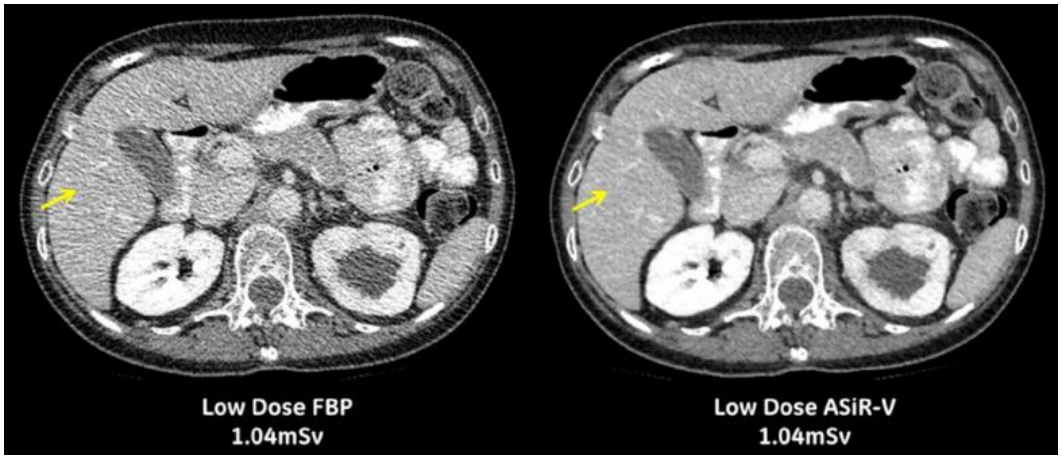
- Noise Index (NI)
  - System estimates image noise with tube current modulation via NI
  - Tube current modulated based on patient's attenuation profile as calculated by scout.
  - Higher NI = more noise in image = lower mA (and vice versa)
  - Clinical need (image quality)





GE Specific Parameters

- ASiR / ASiR-V
  - Iterative reconstruction technique specific to GE
  - Algorithm reduces noise iteratively – comparing the acquired image to a modelled projection.
  - Mixture of FBP and ASiR in 10% increments
    - ASiR 40% = 40% ASiR and 60% FBP.



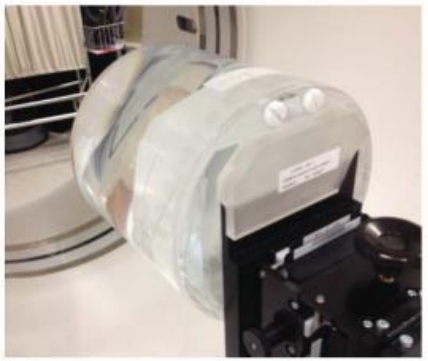
Detector Characterisation

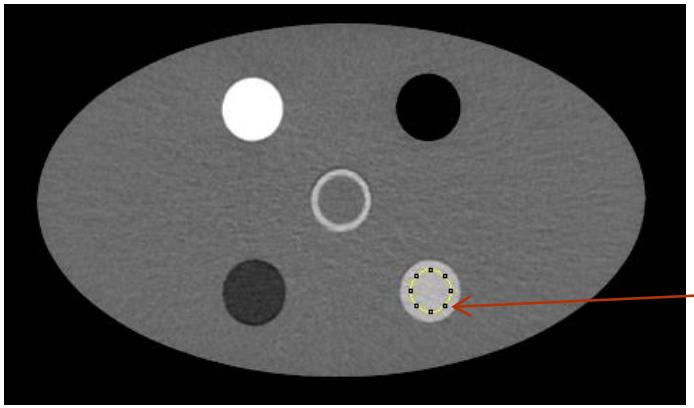
Two phantoms scanned on each scanner using same, fixed dose, protocol*

CelT Phantom

Scan Type	Helical
SFOV	Large Body (large Optima 540)
Detector Coverage	40mm (20mm Optima 540)
Rotation Time	0.6s
Pitch	1.375:1
kV	120
mA	TBC
$CTDI_{VOL}$	4.8mGy
Slice thickness	1.25mm
Reconstruction Algorithm	Standard
ASiR / ASiR - V	0%

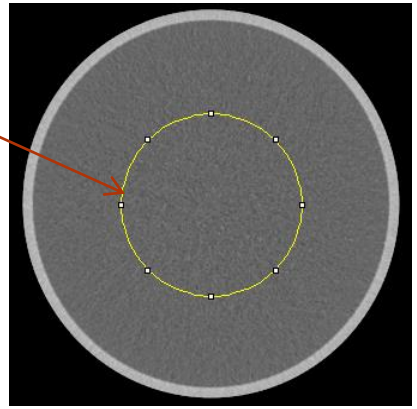
GE Water Phantom





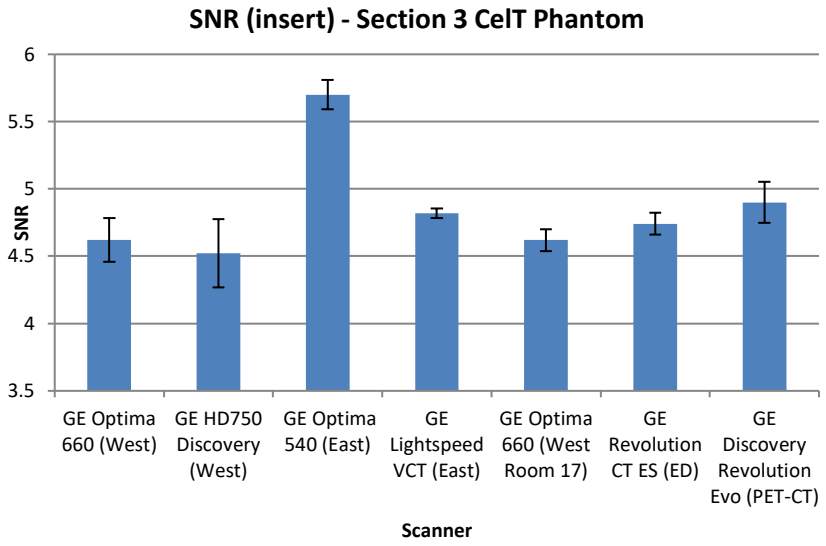
SNR (insert)
= Mean CT no / SD
200mm^2 ROI

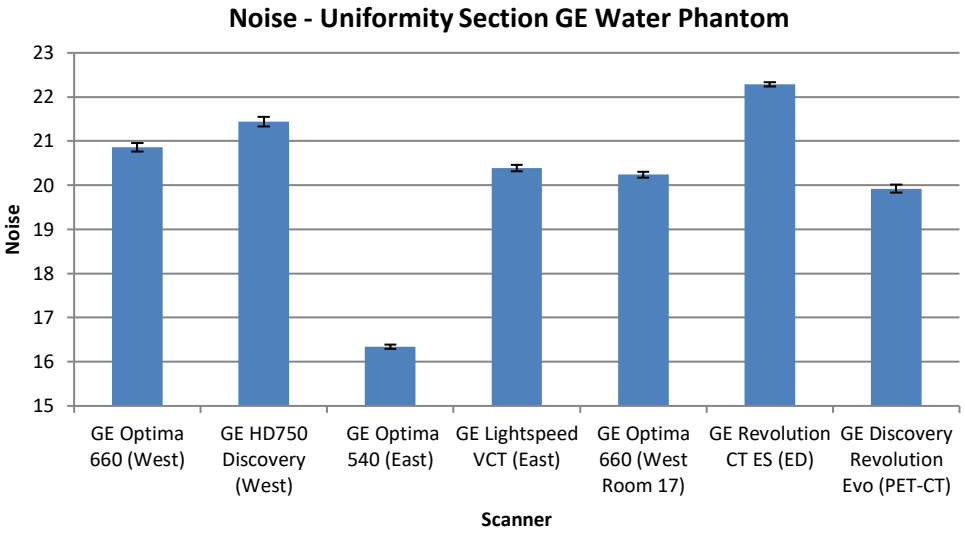
Noise
= SD
8000mm^2
ROI



*Cross calibration between measured and displayed CTDIvol performed (±5% tolerance applied).

Detector Characterisation





Excluding the Optima 540, the mean SNR (insert) measured 4.70 ± 0.14.

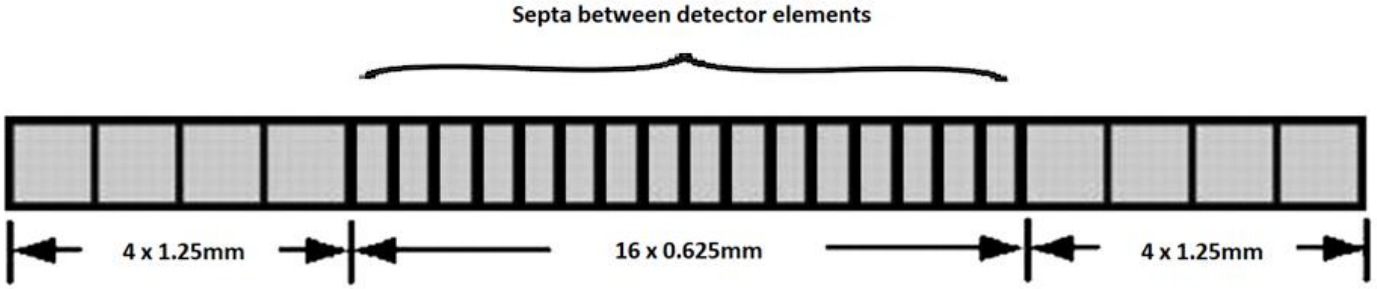
SNR Optima 540 -1.41times the mean SNR for all other scanners.

Excluding the Optima 540, the mean noise measured 20.86 ± 0.88.

Noise Optima 540 - 0.76 times the mean noise for all other scanners.

Optima 540 - Lower Noise?

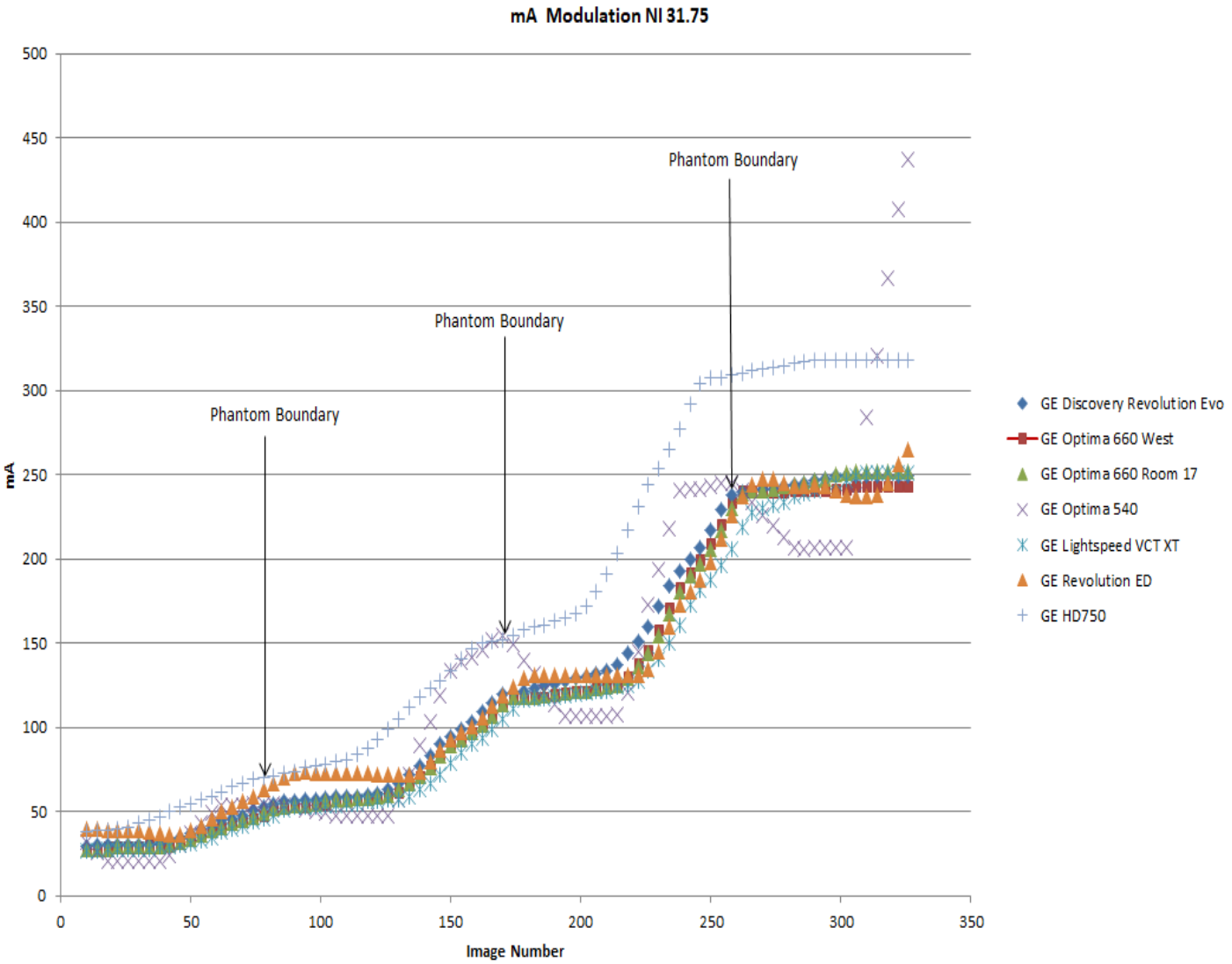
- 2D reconstruction algorithm
  - Introduce lower noise during reconstruction process in comparison to the 64 slice CT (cone beam reconstruction algorithms).
- Design of detector channels
  - No septa separating the outer (1.25mm) detector elements, allowing more photons to reach outer detector elements.



- Nominal helical thickness
  - 33% higher for Optima 540 (all 'plus' mode)
  - More photons available, less noise.

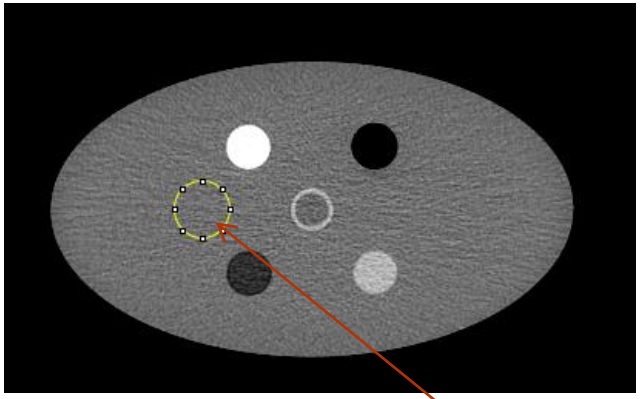
Intra – Scanner AEC Study

Scan Type	Helical
SFOV	Large Body (large Optima 540)
Detector Coverage	40mm (20mm Optima 540)
Rotation Time	0.6s
Pitch	1.375:1
kV	120
mA	Auto & Smart (Smart Revolution)
NI	31.75
Slice thickness	1.25mm
Reconstruction Algorithm	Standard
ASiR / ASiR - V	0%
Scout Order	90,0

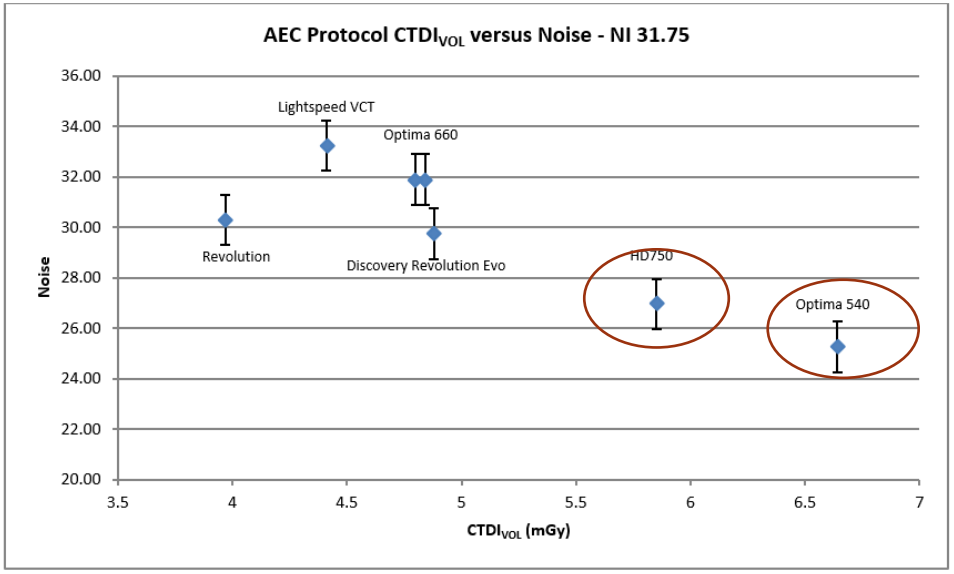


Noise and Patient Dose

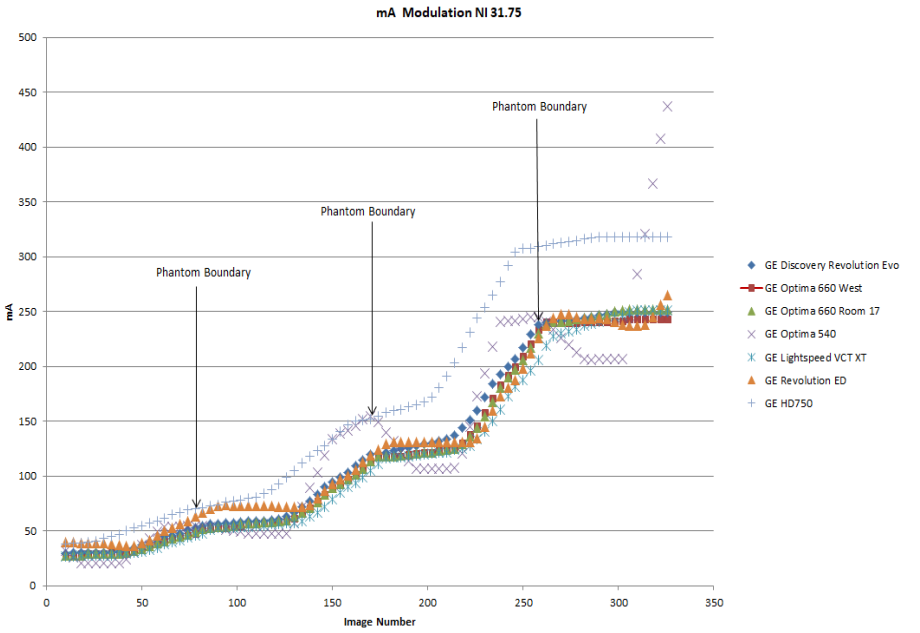
Scanner	Mean Noise	$CTDI_{VOL}$ (mGy)
GE Optima 660 (West)	31.89 ± 0.53	4.84
GE HD750 Discovery (West)	26.96 ± 0.41	5.85
GE Optima 540 (East)	25.27 ± 0.68	6.64
GE Lightspeed VCT (East)	33.23 ± 0.50	4.41
GE Optima 660 (West Room 17)	31.90 ± 0.49	4.80
GE Revolution CT ES (ED)	30.29 ± 0.31	3.97
GE Discovery Revolution Evo (PET-CT)	29.74 ± 0.51	4.88

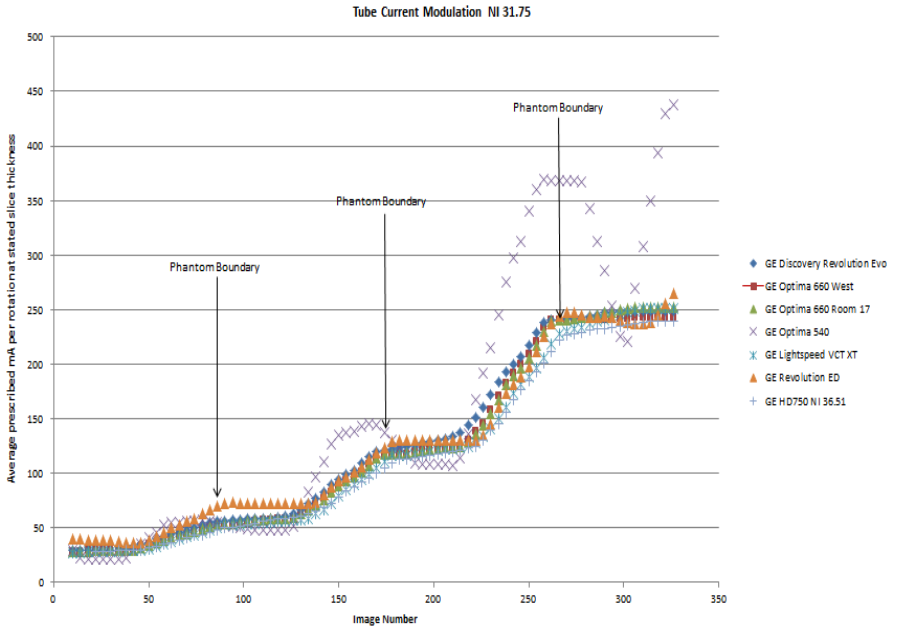


Noise
SD 200mm^2
ROI



HD750 – 11MW44.x (2008)





NI 31.75

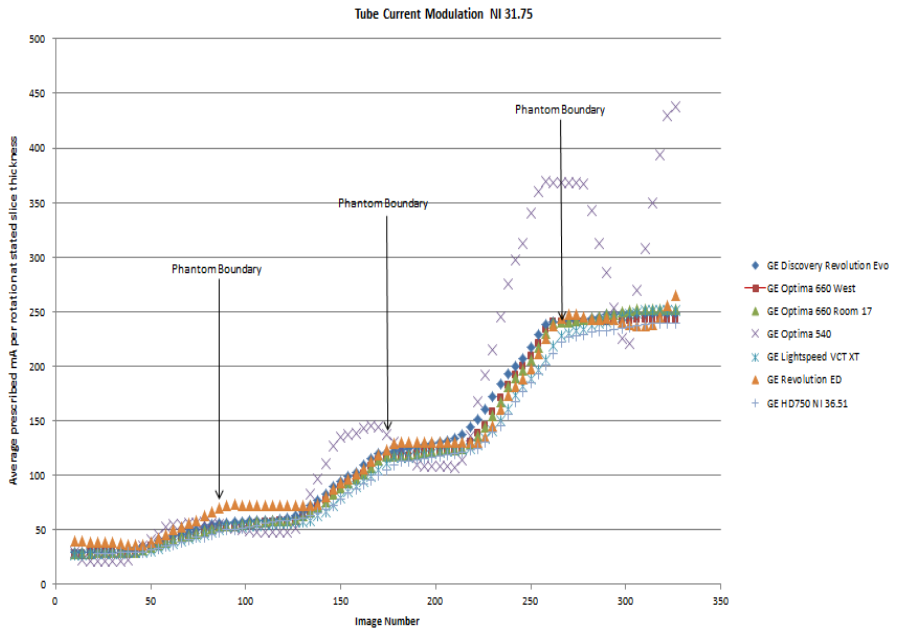
x 1.15

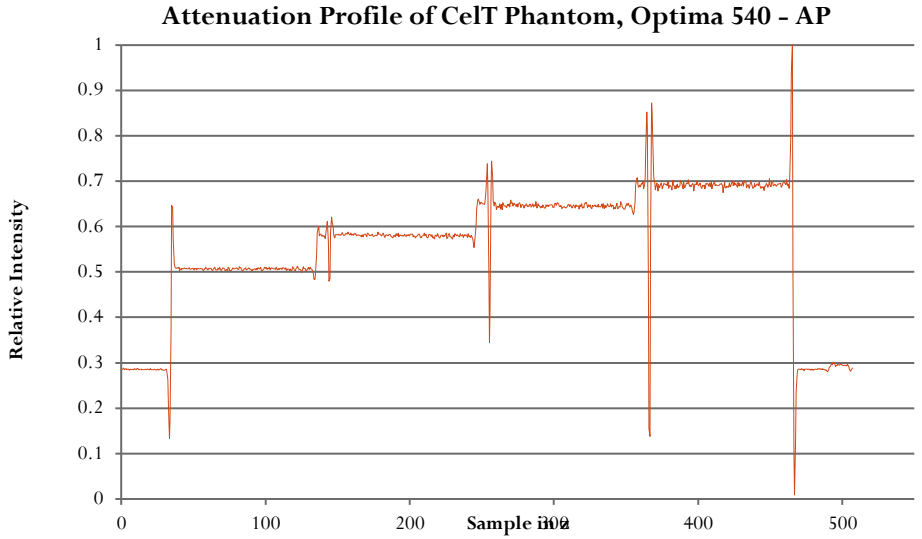
NI 36.51

Optima 540

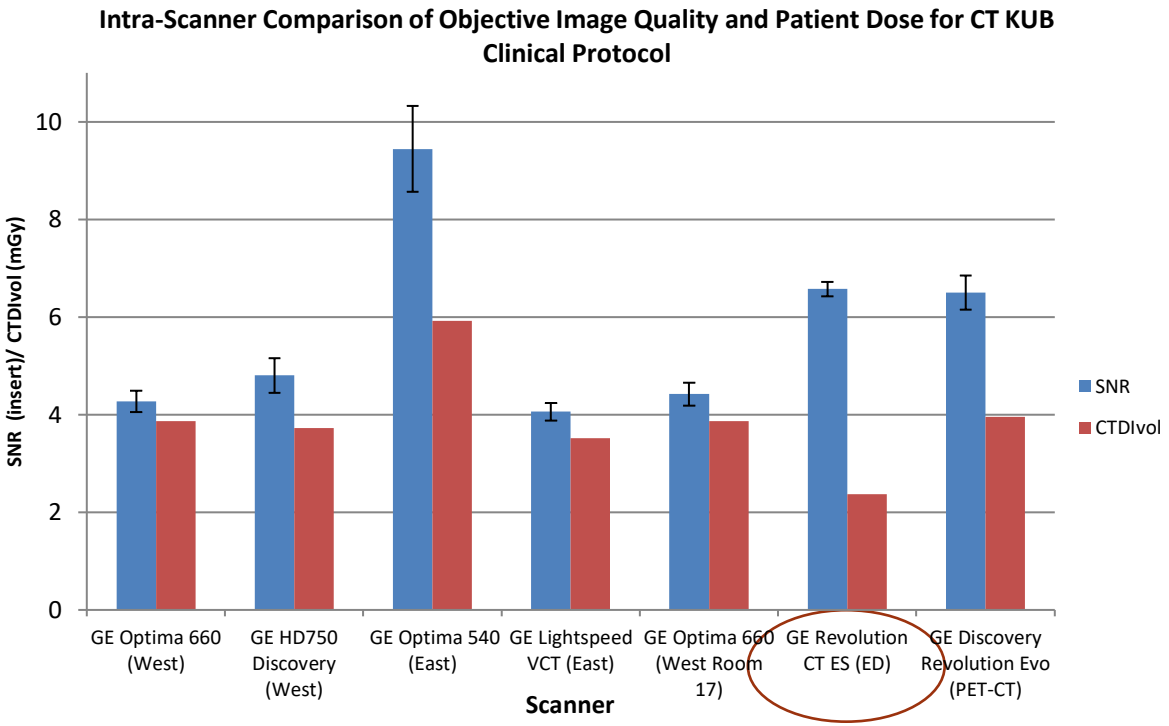
AEC algorithm does not contain the additional step to ensure smoother transitions at anatomical boundaries that later models possess.

Causes a tube current oscillation effect at transitional boundaries for acquisitions acquired on a stepped phantom.





Revolution



Revolution AEC system adjusted the prescribed mA prospectively as per the prescribed ASiR-V%.

Had direct impact on prescribed tube current and hence patient dose.

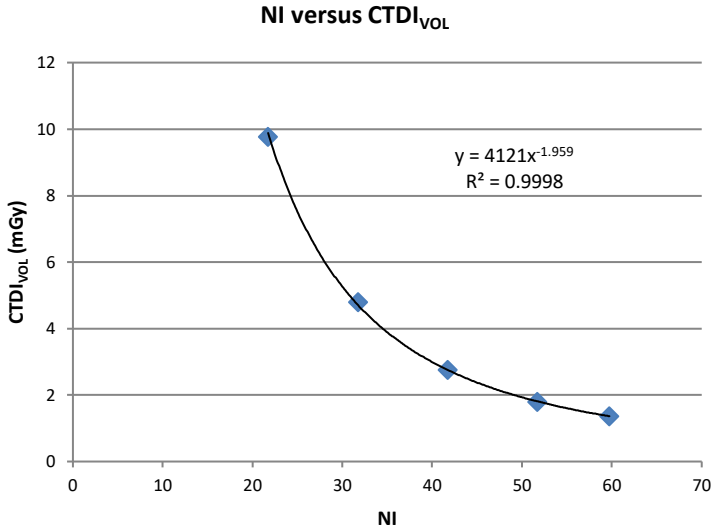
Significantly different to the AEC systems employed on the other scanners.

*All scanners utilised ASiR/ASiR-V 40% apart from Revolution which utilised ASiR-V 50%

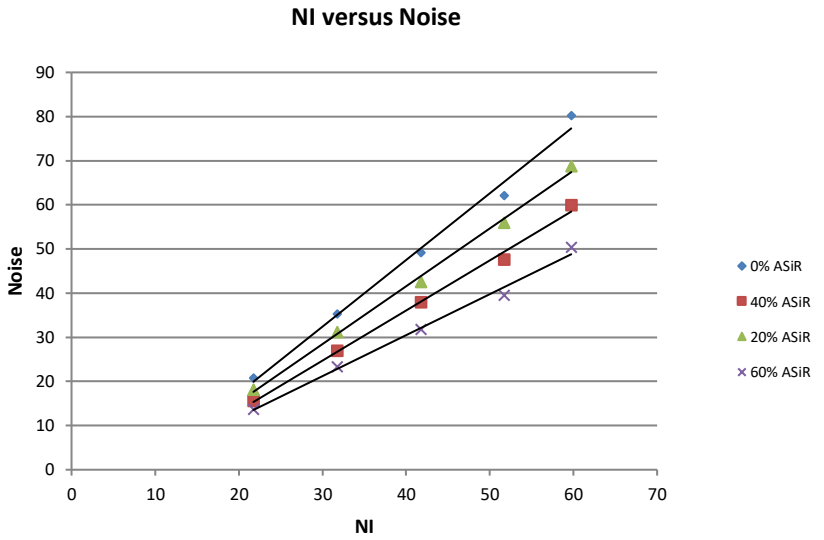
Further AEC Characterisation Work…

Variation of $CTDI_{VOL}$ with NI

$$\frac{Dose_2}{Dose_1} = \left(\frac{NI_1}{NI_2}\right)^2$$



Variation of Noise with NI for different levels of ASiR



Relationship between the NI and $CTDI_{VOL}$ (left) / image noise (right) for the Optima 660

Summary

- Variables in CT optimisation include both detector and AEC characteristics and performance; as well as the exposure parameters.
- Vital to understand the AEC system of CT scanners prior to establishing clinical protocols or undertaking optimisation clinically.
- Subtle differences can lead to significant variations in performance.
- Different manufacturer scanners = further challenges.
- Patient and speciality imaging requirements also influence the optimisation of specific protocols.

Thank you for listening

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