Noise Power Spectrum in CT

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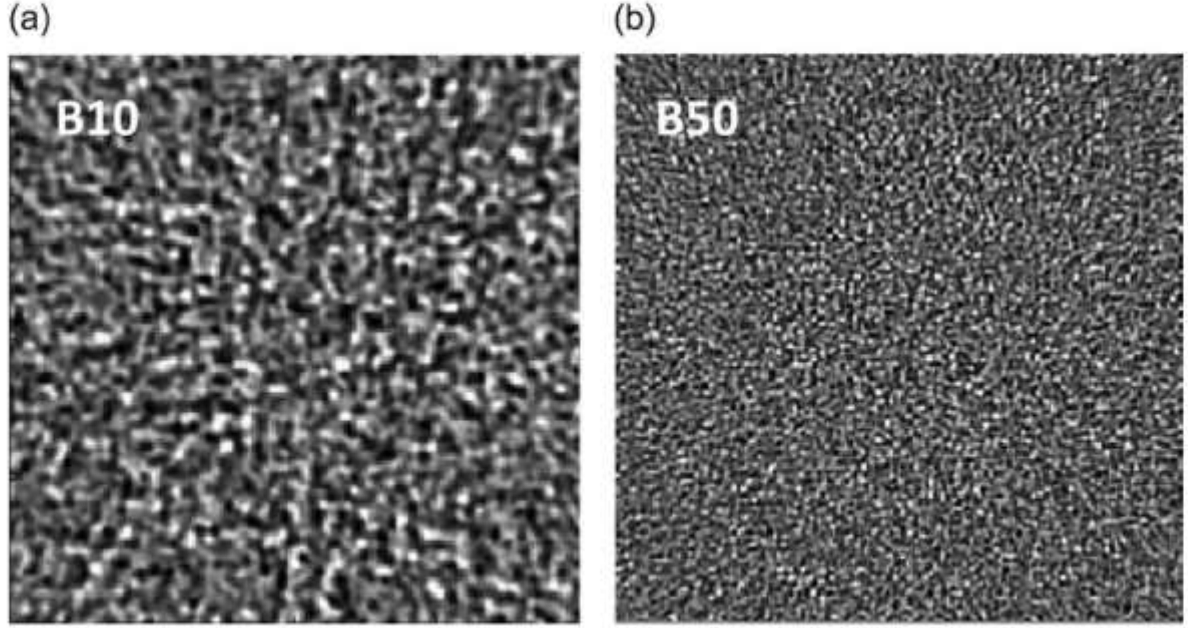
Why measure?

- Appearance of 2 images may be very different, even though the standard deviations are identical



- SNR does not completely characterise the noise
- Noise texture important too – i.e. the spatial frequency distribution of the noise
- NPS gives a more complete description of noise than standard deviation – describes noise variance as a function of spatial frequency, therefore characterising noise texture

Calculating the NPS

- Starting with trying to calculate the NPS for a series of images
- Following methodology described in:

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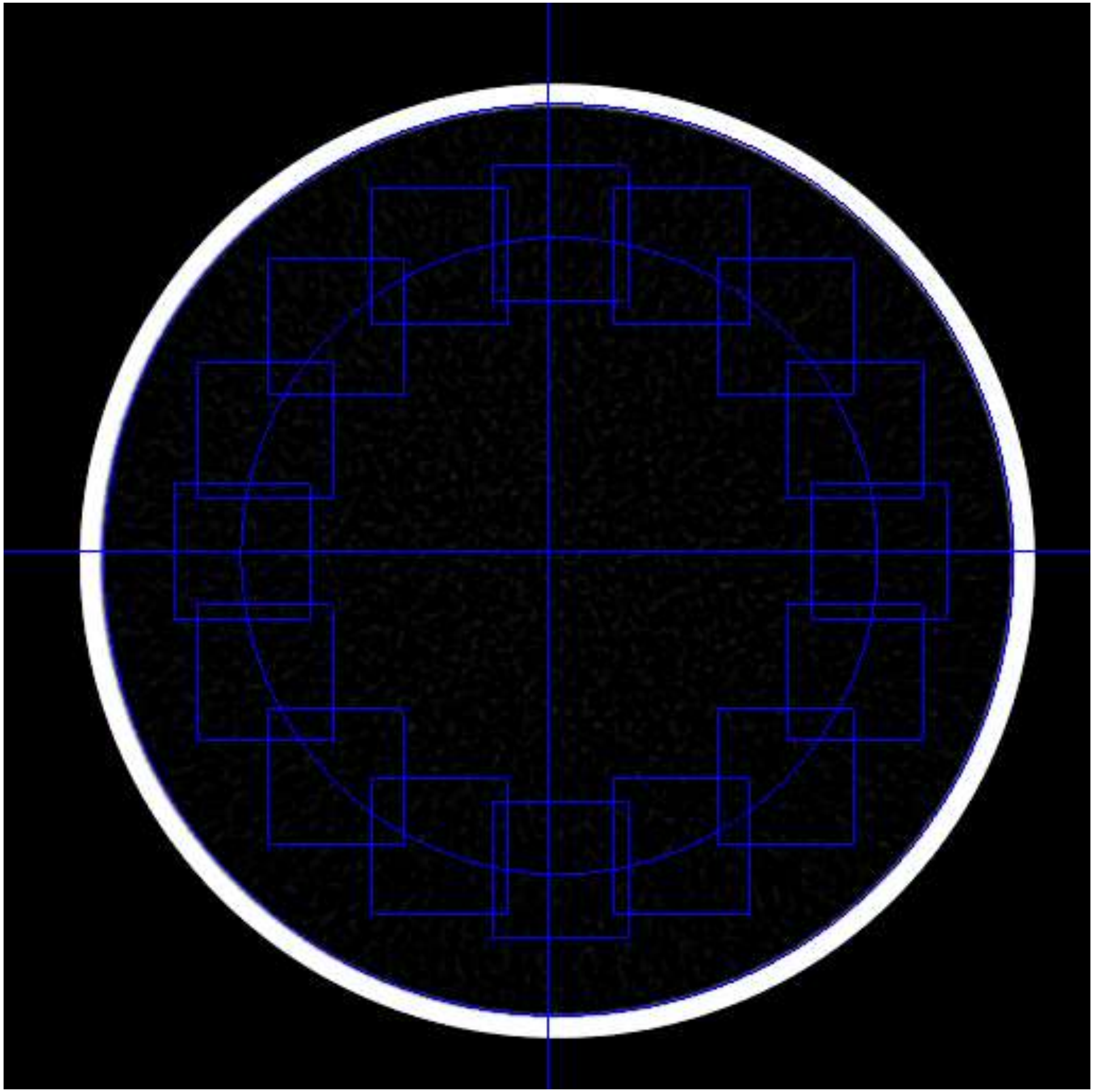
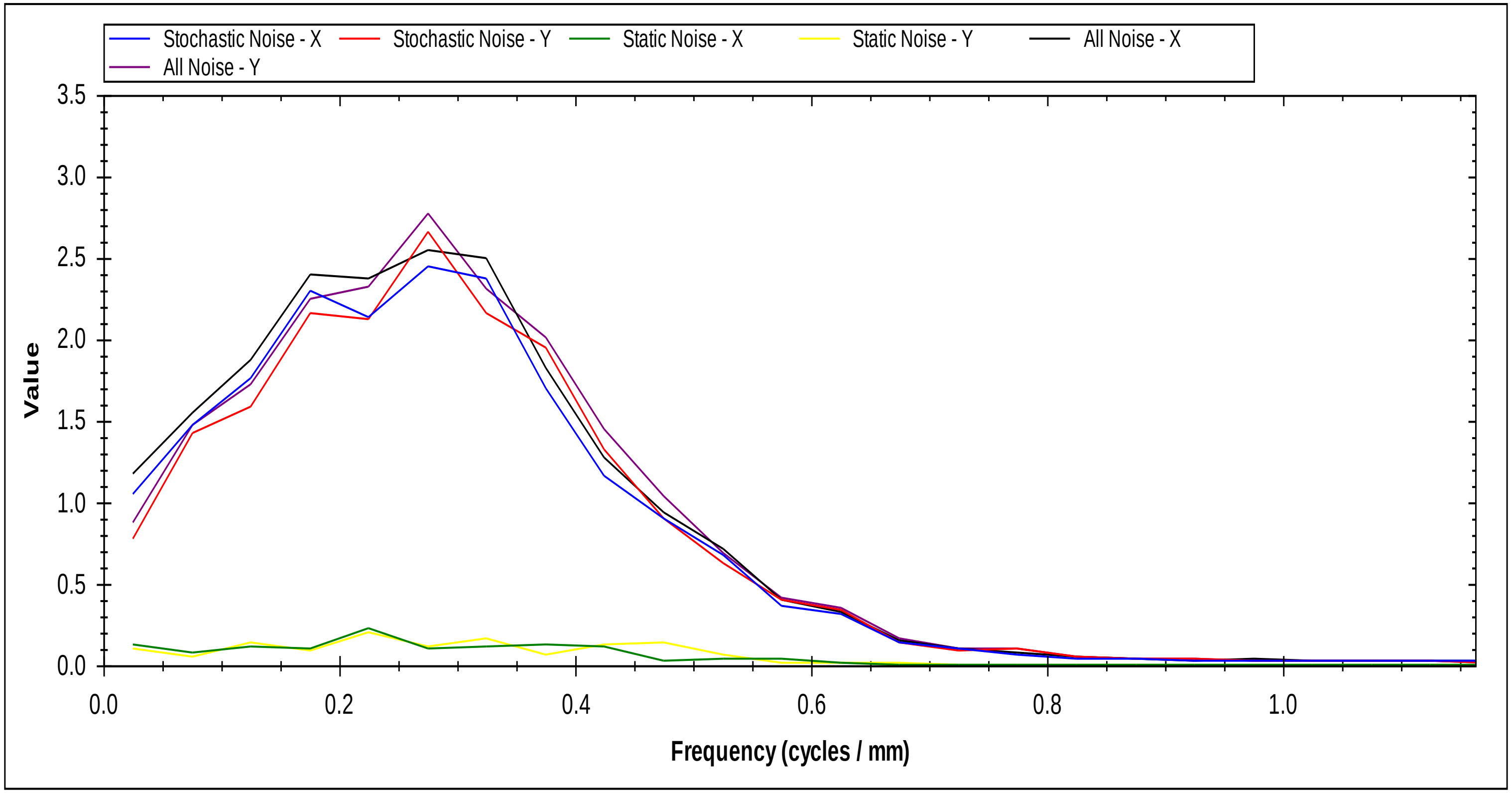
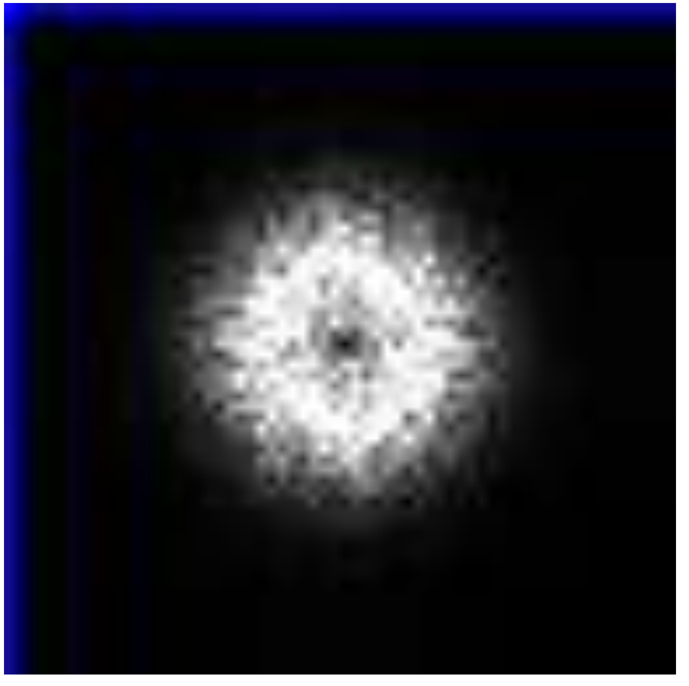
- Acquired series of helical images using a homogeneous Px phantom
- Written an analysis tree in IQWorks to calculate the average NPS for ROIs positioned at a constant radius within one image



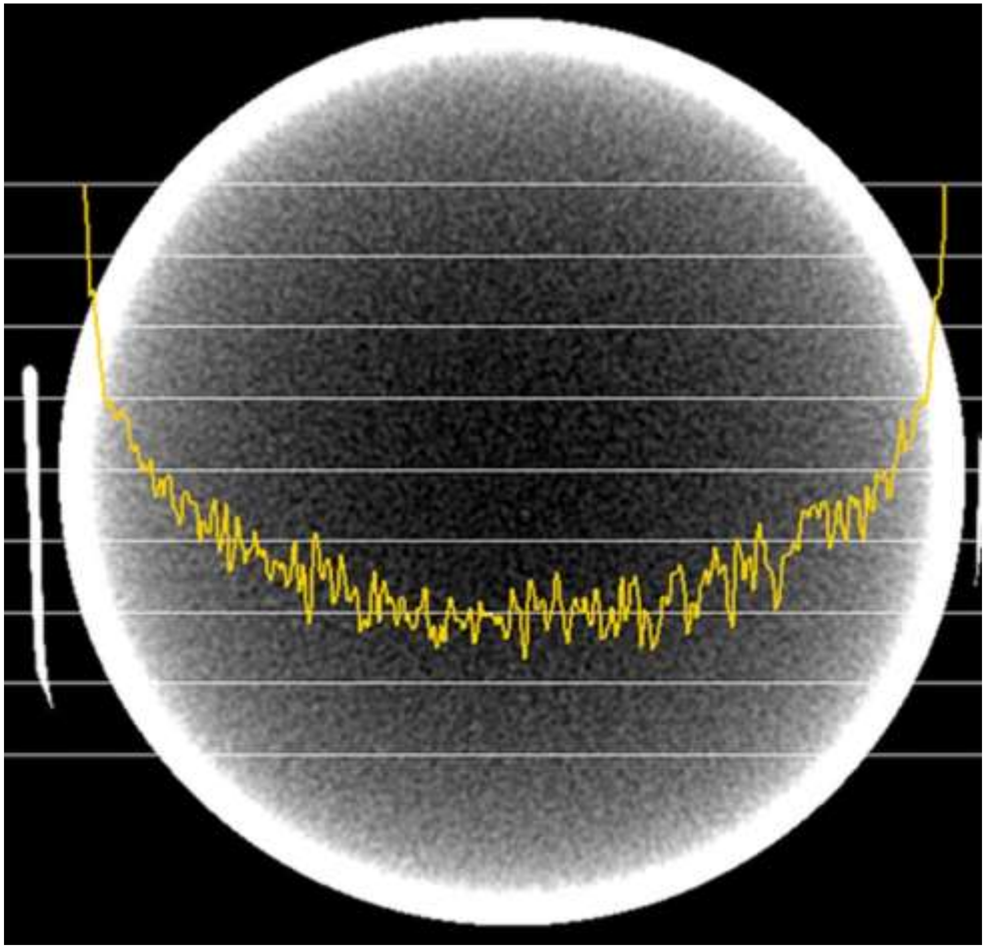


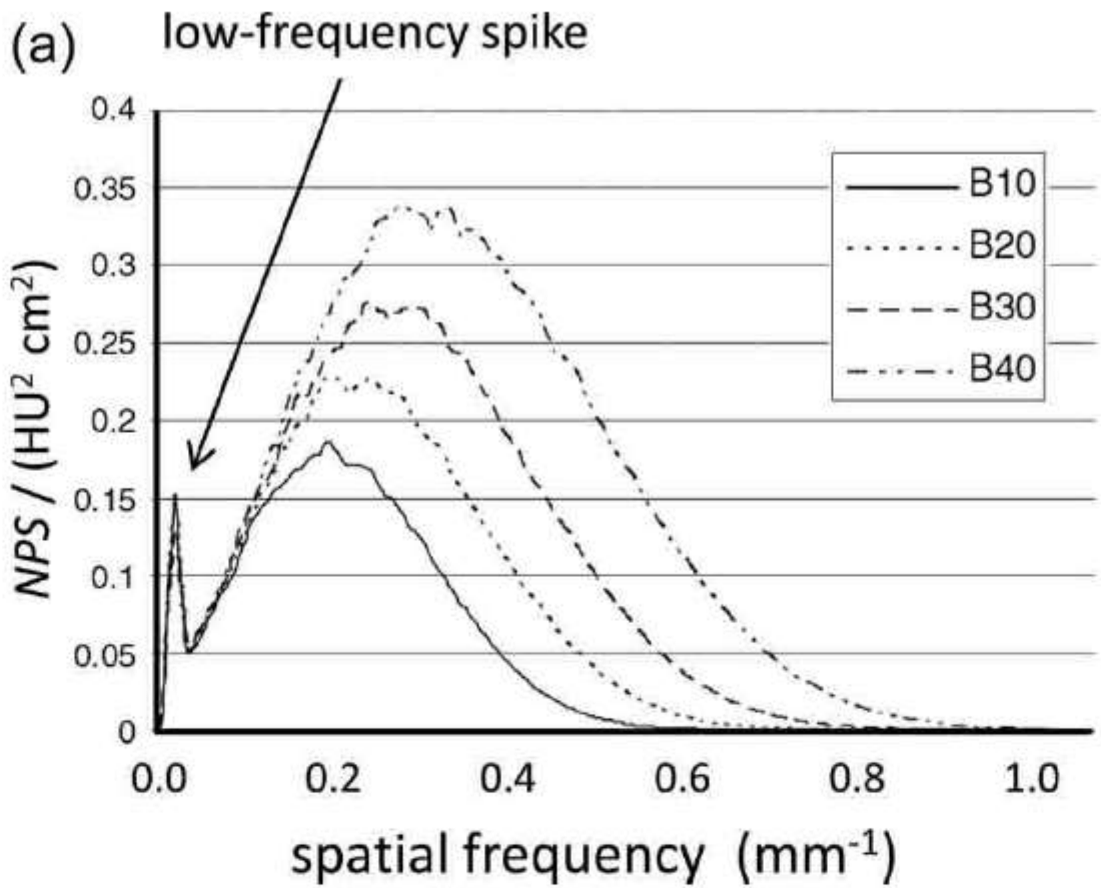
Stochastic Noise - X
Stochastic Noise - Y
Static Noise - X
Static Noise - Y
All Noise - X
All Noise - Y
Value
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.0
0.2
0.4
0.6
0.8
1.0
Frequency (cycles / mm)



Next step

- In CT, there is a cupping artefact, i.e. HU units near the centre of the image of a homogeneous object are lower than those nearer the periphery
- Caused by e.g. beam hardening and scattered radiation
- This can cause a spike at low frequencies in the NPS





(a)
low-frequency spike
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
NPS / (HU2 cm2)
B10
B20
B30
B40
0.0
0.2
0.4
0.6
0.8
1.0
spatial frequency (mm-1)

To reduce the impact of cupping on the NPS

- One way of eliminating the spike is to acquire images for two helical runs of the same length of a homogeneous phantom, then subtract one data set from the other
- Also subtracts out any non-uniformity in the images due to inhomogeneities in the phantom, i.e. only the noise remains
- I would then calculate the average NPS over each of the ROIs in each of the difference images

The problem – when using IQWorks

- I can load a pair of images and subtract one from the other (using Maths – Process – Difference Image)
- I can load a series of images
- But I can’t read in 2 series of images and subtract each image in set 2 from the corresponding image in set 1

IQWorks - development

- Andrew Reilly looking at 2 things:
  - Modifying IQWorks so that it can handle the 2 image sets
  - Automating generating the layout of over-lapping regions of interest

Another question

- The reference

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suggests that we should be extending to doing this in 3D

- This is for systems where the raw data is acquired by many detector arrays simultaneously in the z-direction. i.e. volume scans, cone beam. Thus giving rise to noise correlation in z
- Extension to equations –not yet available in IQWorks
- How to do this????

So why useful?

- To assess noise fully
- Could use to compare protocols (including selection of reconstruction filter) for CT scanners from different manufacturers
- i.e. could match recon filters for the different manufacturers
- Could use to compare noise versus dose for different scanner models (if keep dose delivered constant for all)
- Will supplant the use of visual assessment of low-contrast test phantoms at acceptance/routine QA