Using X-Ray Quantum Correlations to Revolutionize Bio-Imaging

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How many photons does it take to make an image?

- How do we define contrast, SNR, and variance?
- What parameters can affect SNR and variance?

$$C = n_s/n_b$$

$$\mathrm{SNR} = C\sqrt{An_b}$$

$$\sigma^2 = \frac{1}{d^2}\sum_{i,j}^{d}\left(A[i,j] - S[i,j]\right)^2$$

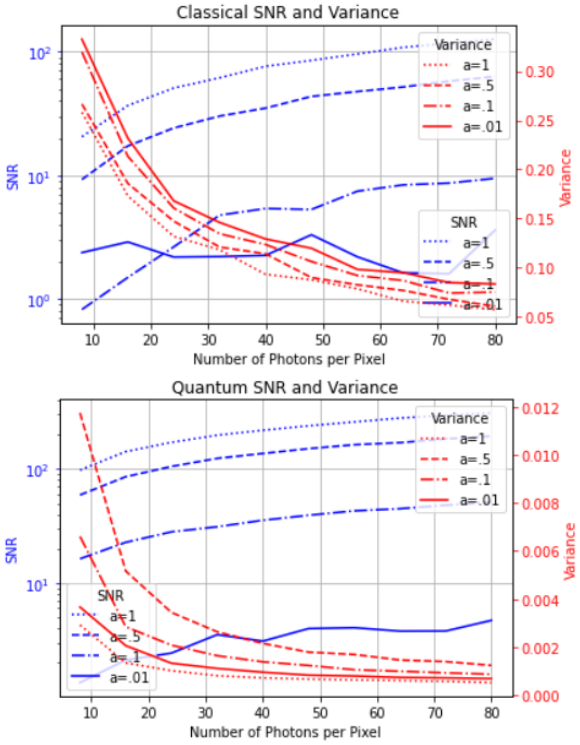
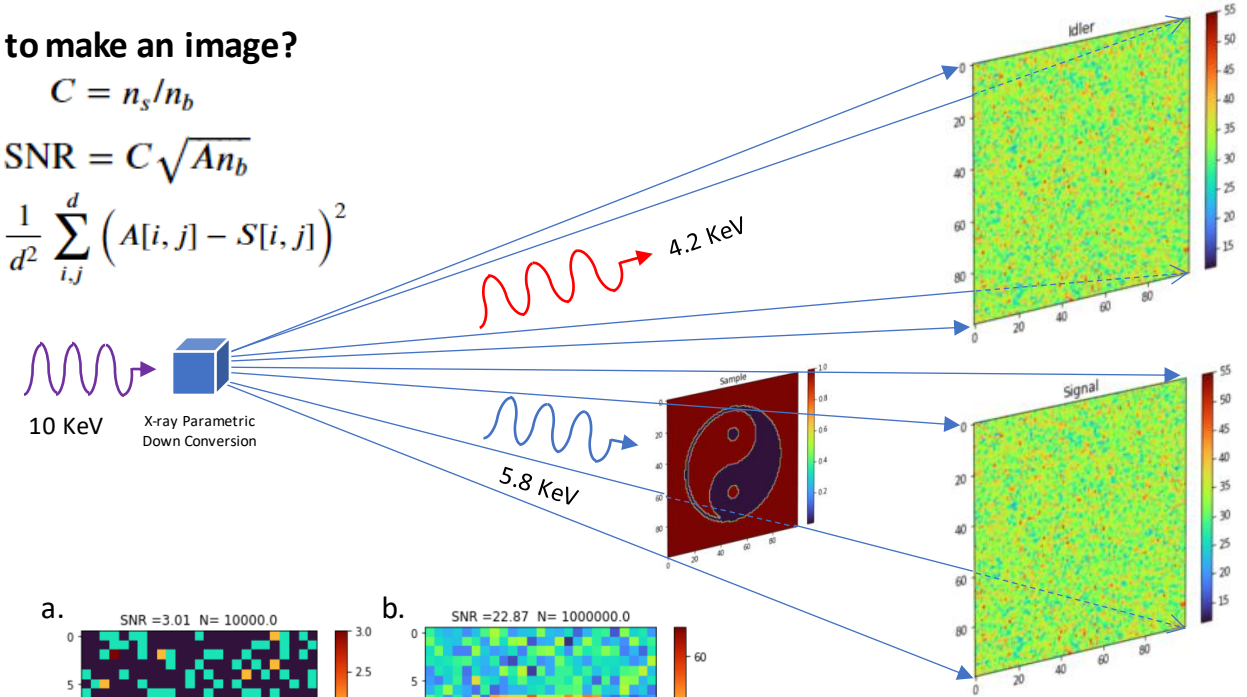


Fig. 2. Absorption is denoted by 'a' in the legends. SNR increases and variance decreases with increasing average number of photons per pixel. SNR also increases with increasing absorption. Square samples used in all cases.



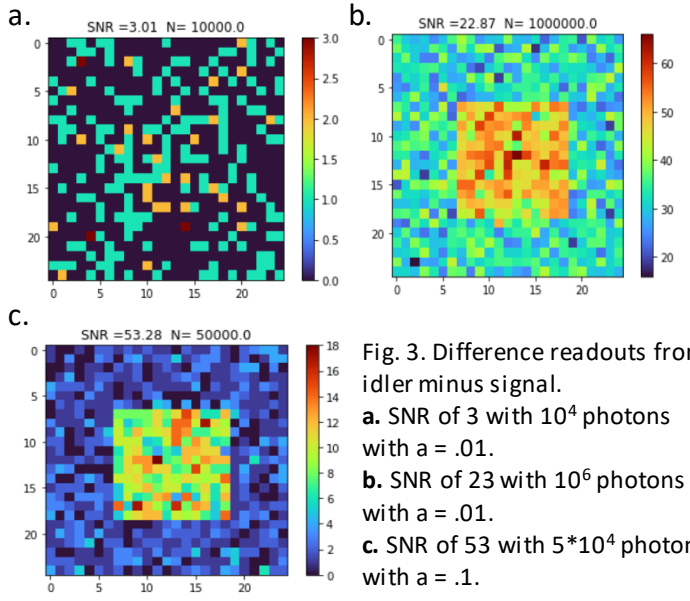


Fig. 3. Difference readouts from idler minus signal.
a. SNR of 3 with 10^4 photons with a = .01.
b. SNR of 23 with 10^6 photons with a = .01.
c. SNR of 53 with $5*10^4$ photons with a = .1.

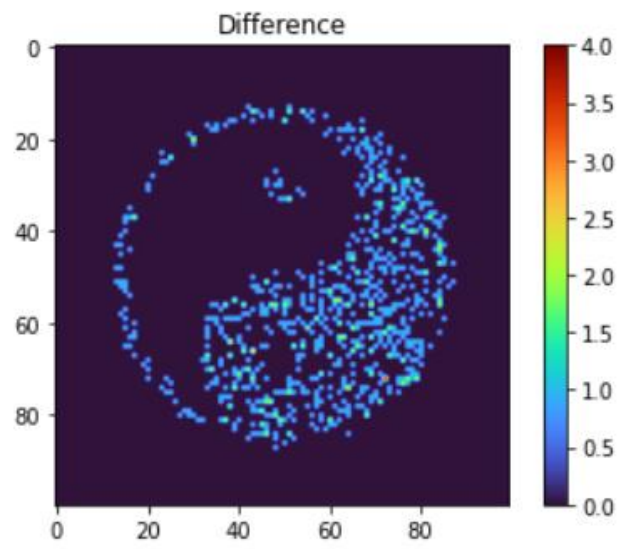


Fig. 1. Subtracting pixel-by-pixel the signal readout from the idler, revealing the hidden yin-yang symbol. Photon count of ~336,000. Sample is 99% transmissive and 100x100 pixels.

What do we know (and don't know)?

- SNR is improved by employing the quantum scheme over classical but is tricky to define.
- Variance is greatly improved by the quantum scheme due to the implementation of the idler detector.
- How does the variance depend on absorption in the quantum scenario?
- What is a better way to define the SNR?

References

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- Sofer S. et. al. Quantum Enhanced X-ray Detection. J Phys. Rev. X. American Physical Society. 2019 Aug. doi: 10.1103/PhysRevX.9.031033.