Reducing Dose While Maintaining Image Quality for Cone Beam Computed Tomography

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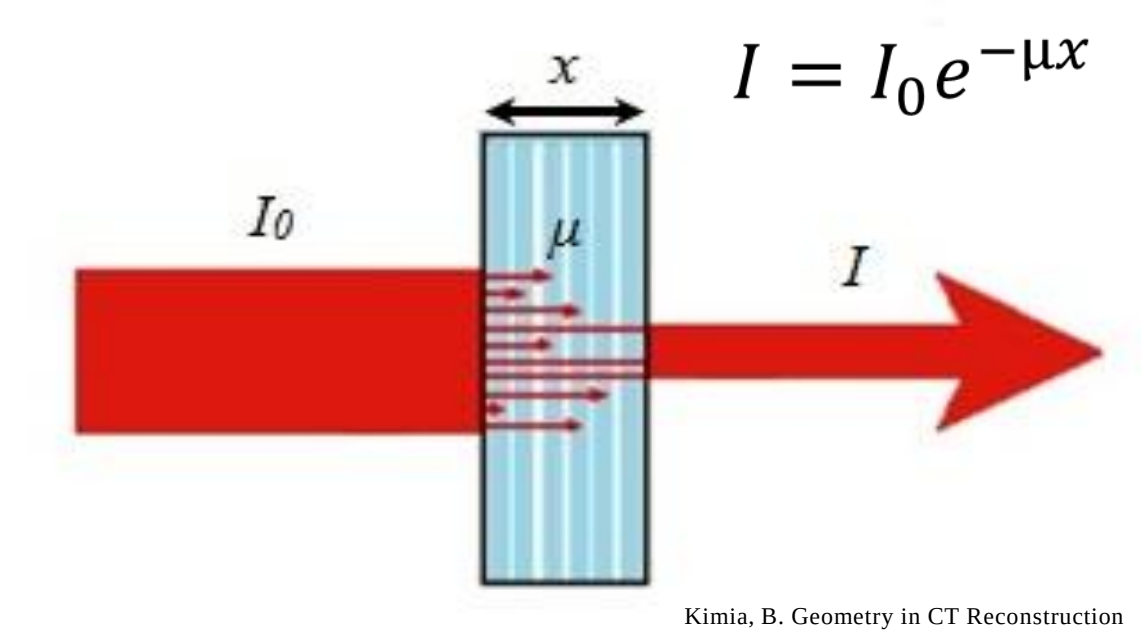
X-Ray Attenuation

I_0: X-ray beam intensity

I: Beam intensity after passing through object

x: Length of x-ray path through object

μ: Attenuation coefficient



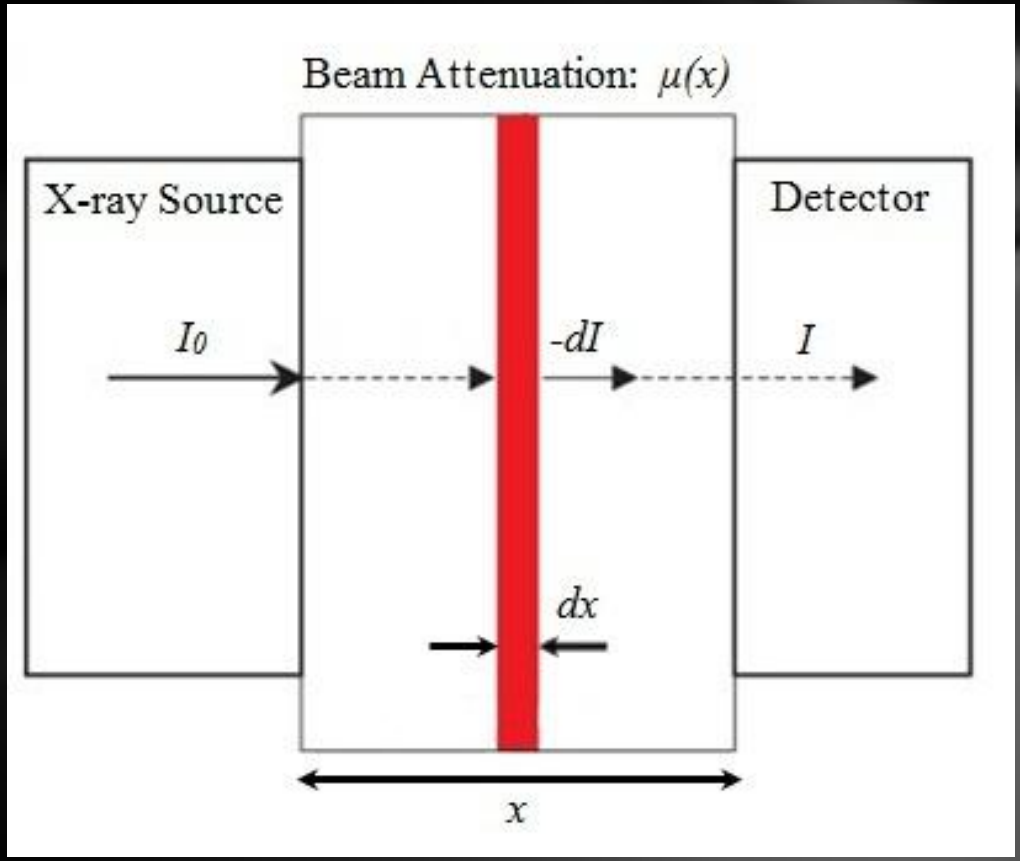
Kimia, B. Geometry in CT Reconstruction

Lambert-Beer Law

$$-dI \propto Idx$$

$$dI = -\mu(x)Idx$$

$$I = I_0 e^{-\int \mu(x)dx}$$



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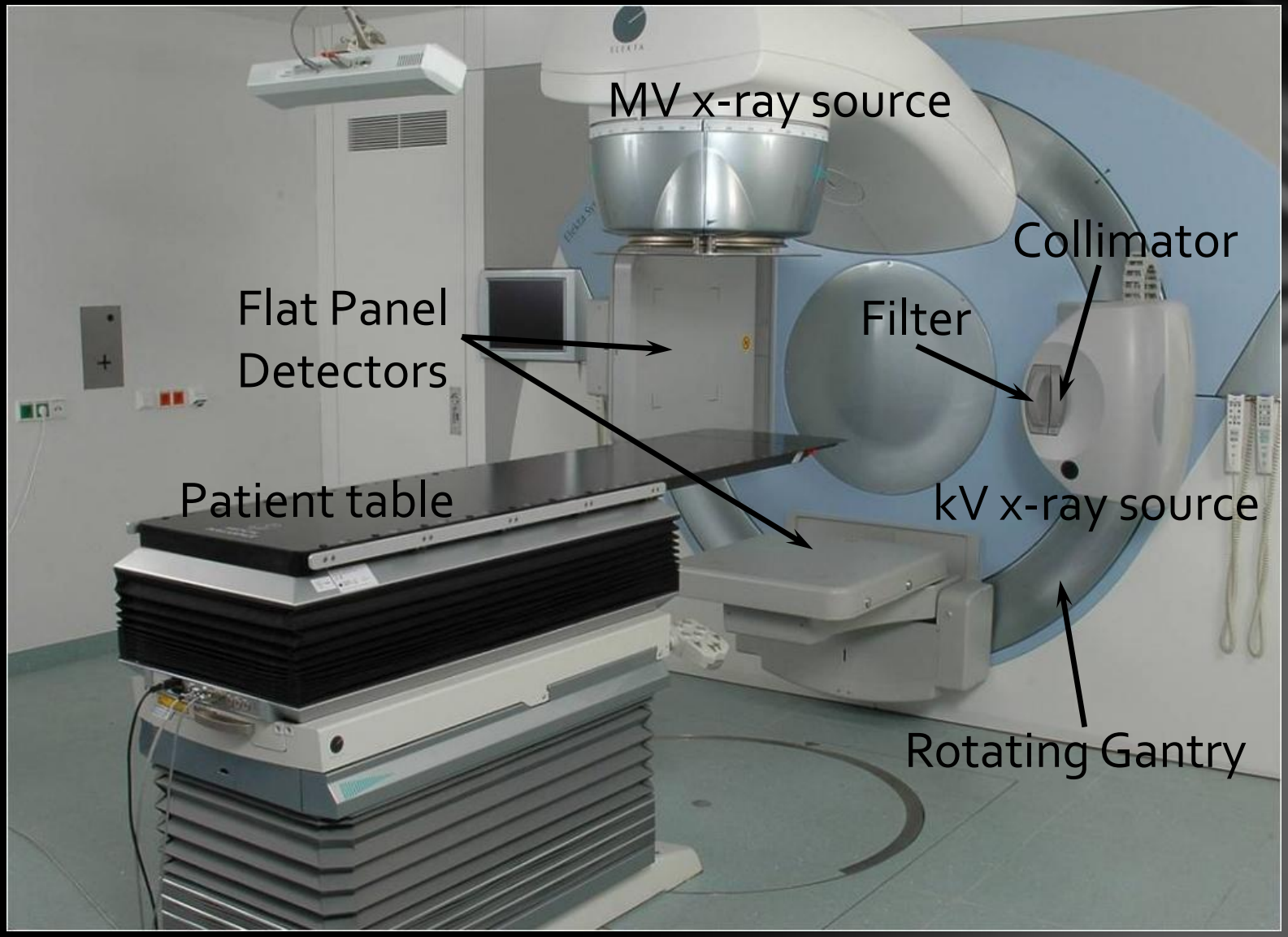
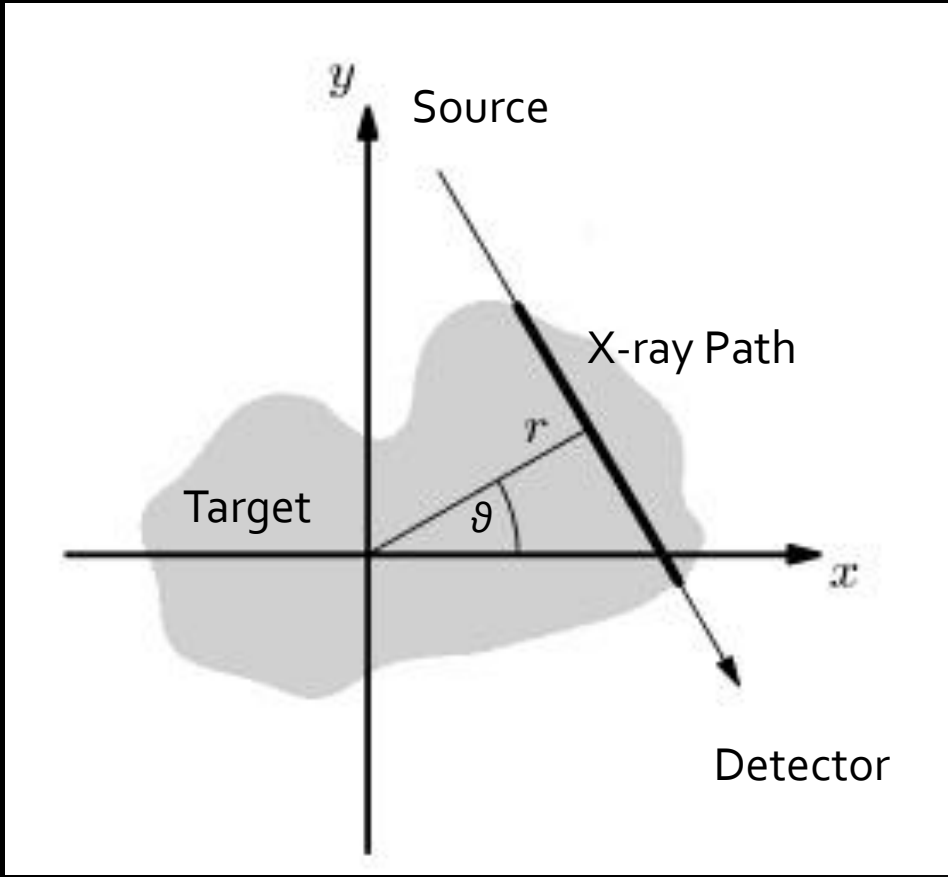
Apparatus


MV x-ray source
Collimator
Flat Panel Detectors
Filter
Patient table
kV x-ray source
Rotating Gantry

CT Image Reconstruction



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r: Orthogonal distance of beam path to origin

ϑ: Normal vector of the beam path

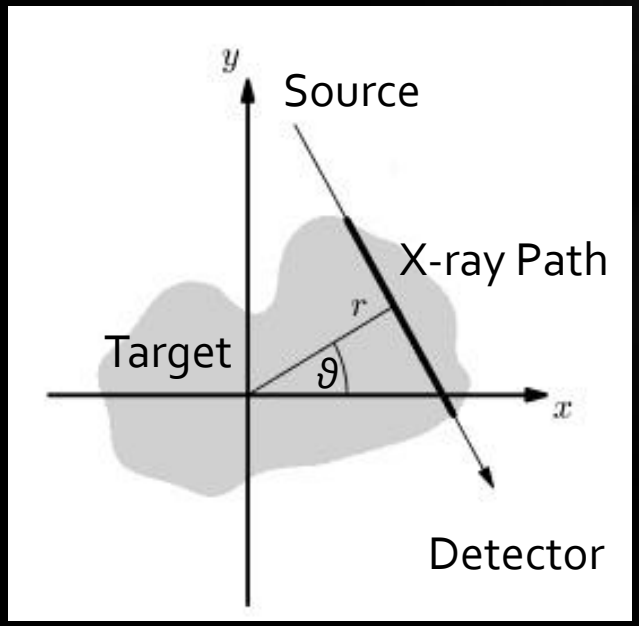
Radon Transformation

$$I = I_0 e^{-\int \mu(x)dx} \Rightarrow \ln\left(\frac{I_0}{I}\right) = \int \mu(x)dx$$

$$P(r,\theta) = \int \mu(x,y)ds$$

Projection

Image to be reconstructed



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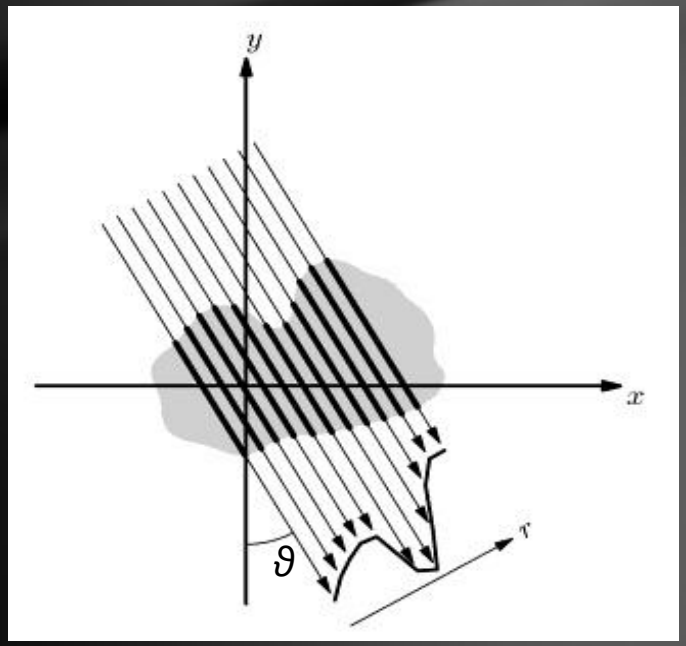

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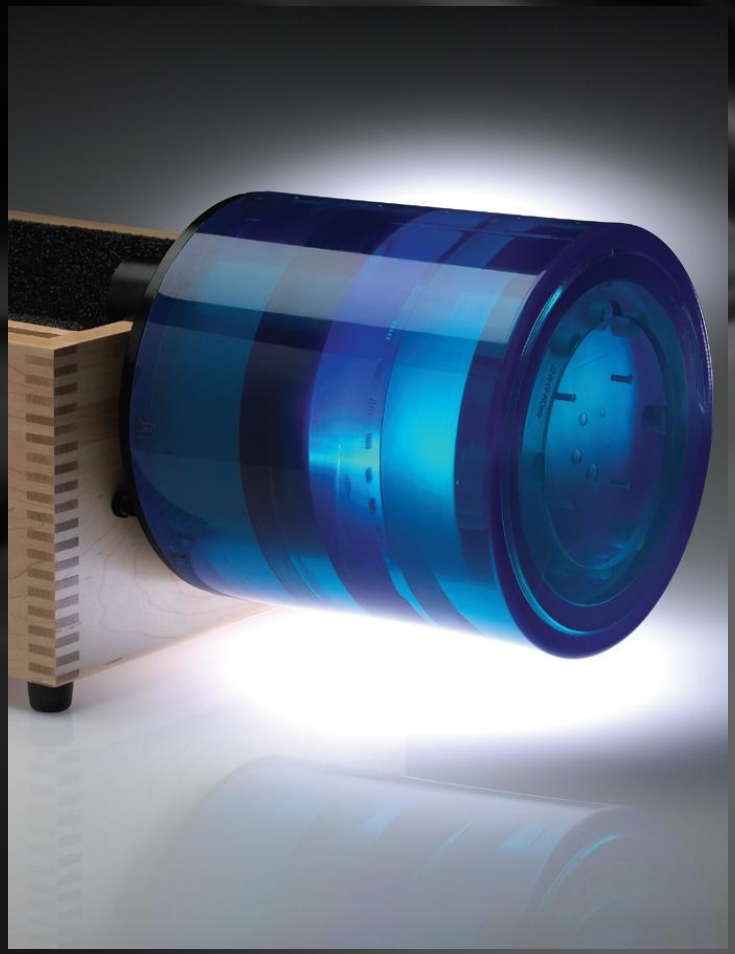
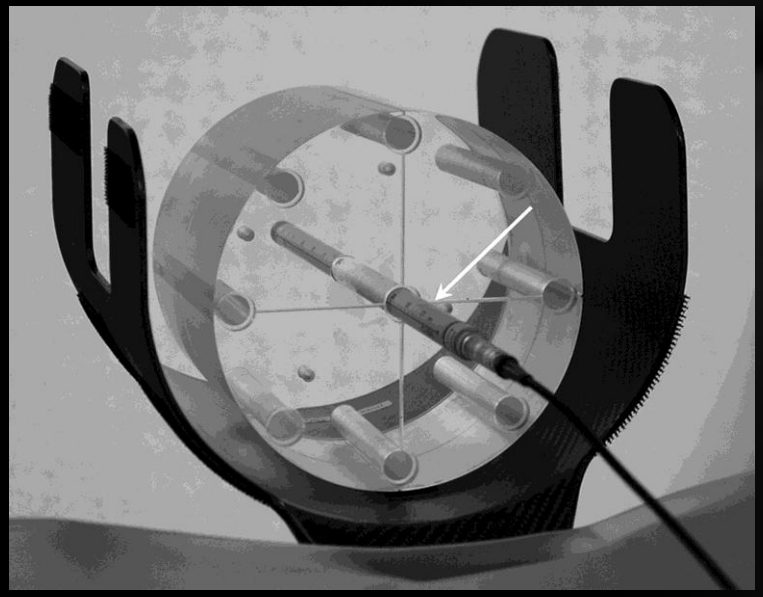
Research Motivation

- Reducing radiation to patients
- Minimize scan time
- Ensure adequate image quality

Experimental Methods

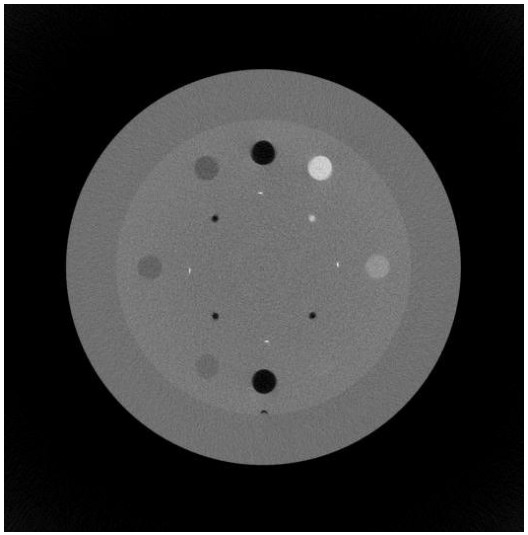
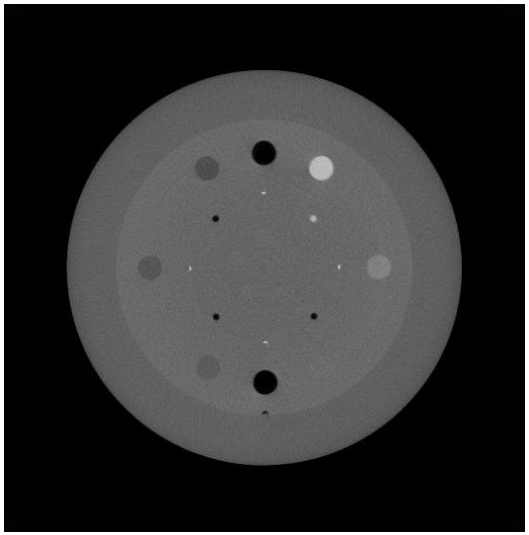
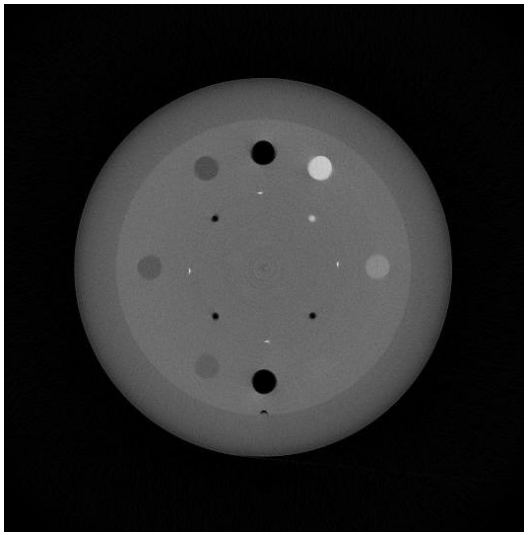
- Scan phantoms
  - Catphan
  - Pelvis phantom
- Vary preset settings
- Measure Dose



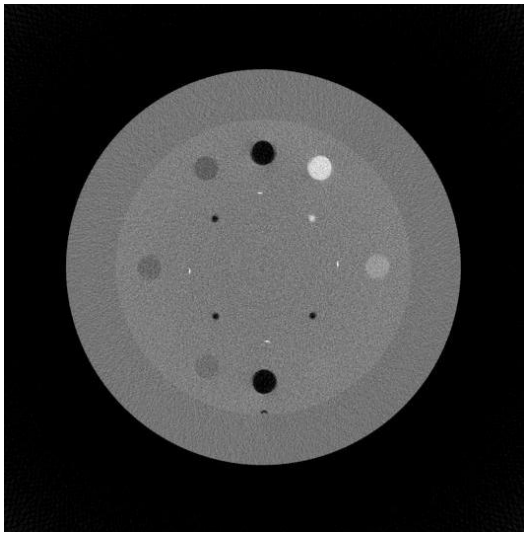
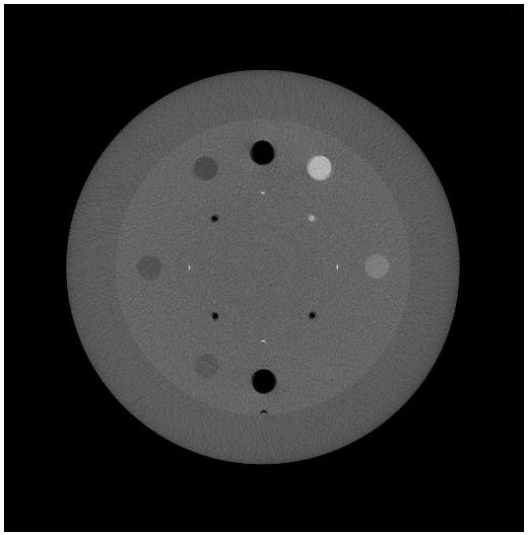
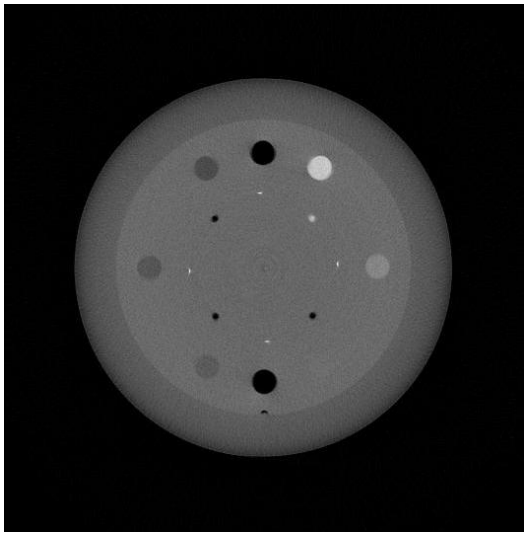


Scan Presets

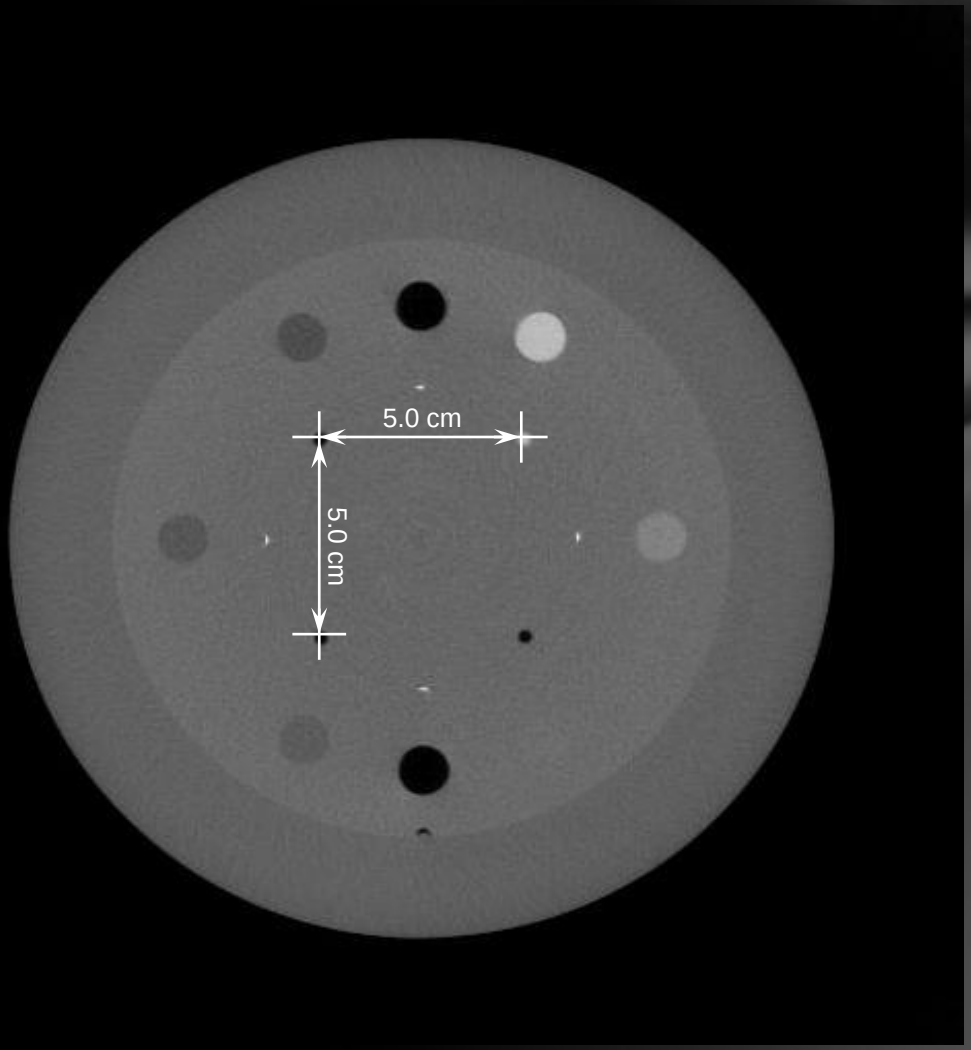
Pelvis: 20 mA, 40 mA, 80 mA

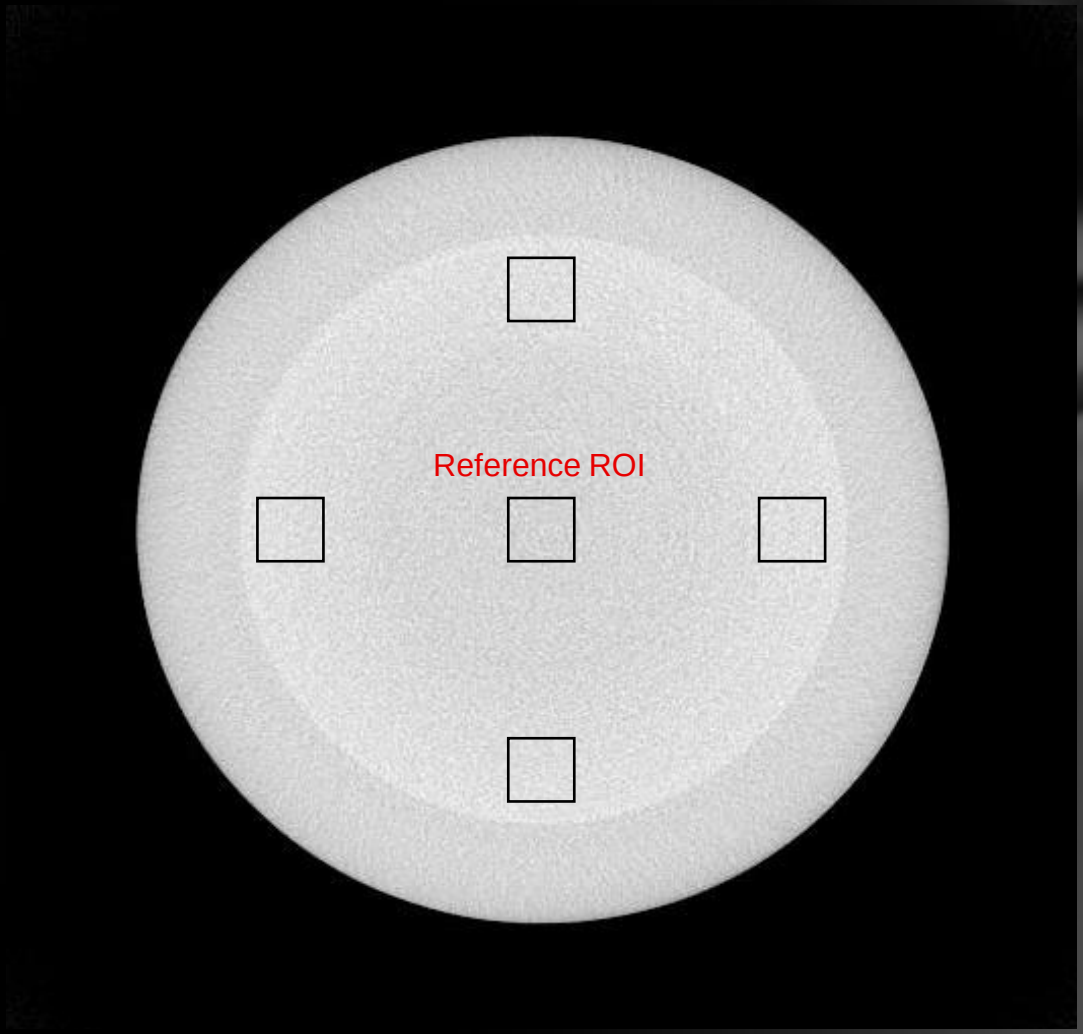
Fast Pelvis: 20 mA, 40 mA, 80 mA

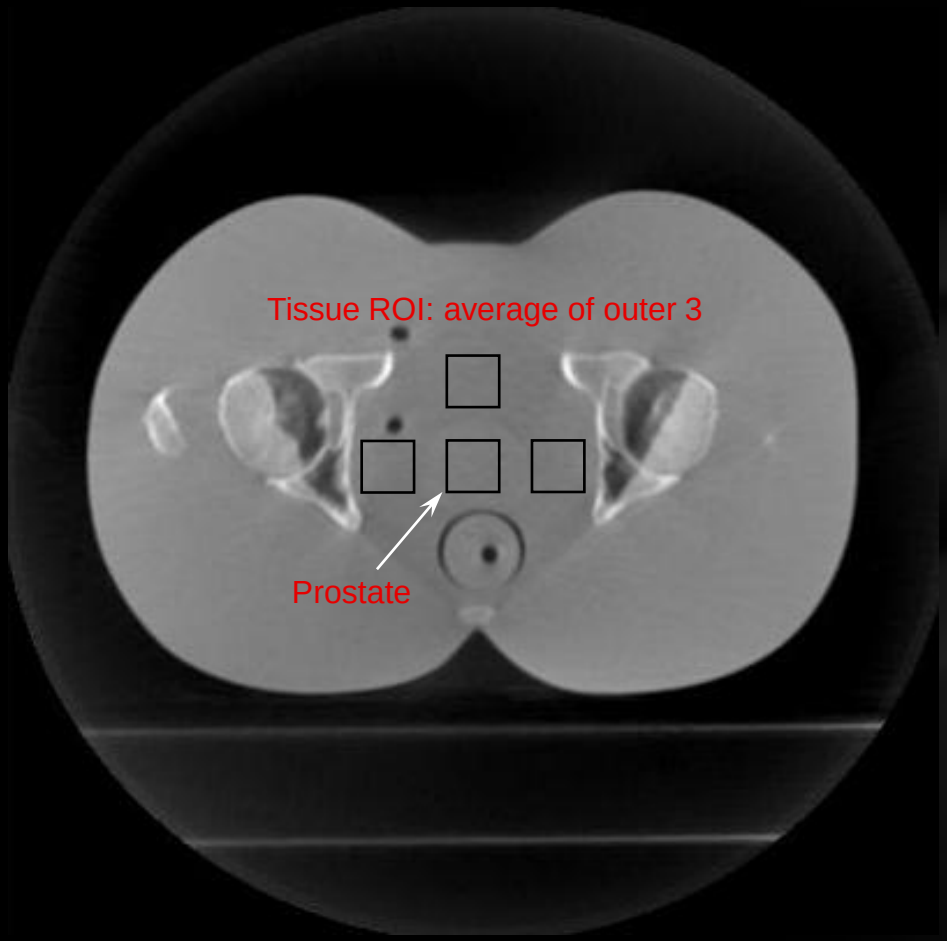
Analysis: Image Geometry



Analysis: Image Uniformity



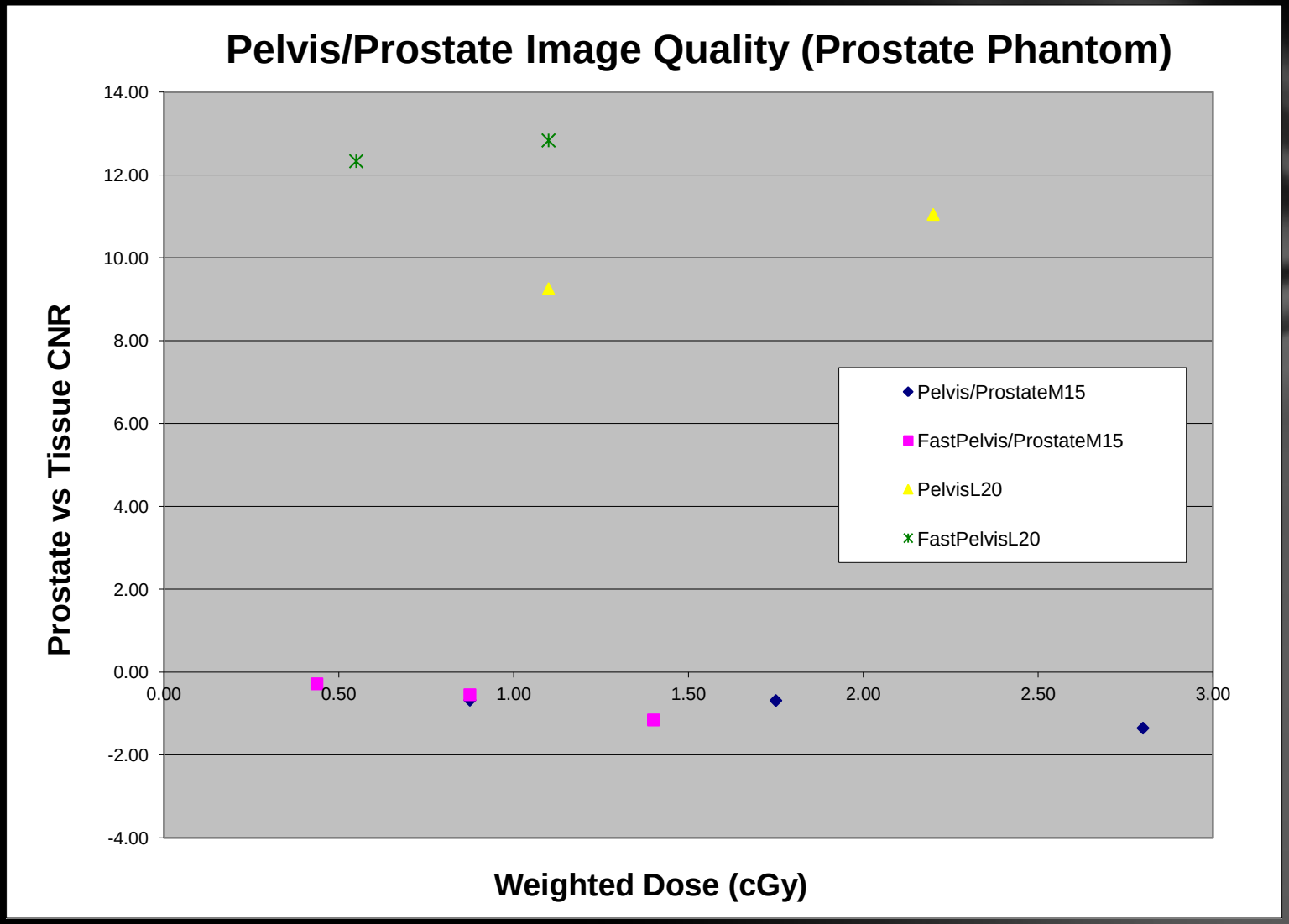
Analysis: CNR



Contrast-to-Noise Ratio

$$\frac{m_{prostate} - m_{tissue}}{\sqrt{s^2_{prostate} + s^2_{tissue}}}$$

Results: CNR vs Dose



Conclusion

- The Bottom Line: Faster is better and less is more
- Patients can be exposed to less dose!

Acknowledgements

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Questions?