Spectral X-ray Implications for Attenuation and Scatter-based Tomography

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Dual Energy Subtraction
(Use of Kedge of x-ray attenuation)

X-ray Attenuation (cm⁻¹)

Iodine

Tissue

A

B

~30

X-ray (kV)
Siemens Somatom M8 Dual-Tube, 0.33 sec rotation, 64-Channel CT Scanner
Spectral CT - Philips
Medipix X-ray Imaging Array

ARRAY

PIXEL

x1825A (x1800/x1825)
Fig. 1. A typical X-ray event in a detector. The primary photon is captured by a photoelectric event. A fluorescent photon is emitted and captured in the next pixel. The charge cloud from these two interactions widens by diffusion during drift towards the readout electrode (only one type of carrier shown). It should be noted that most of the energy is deposited outside the pixel where the primary interaction occurred.

Scatter Types

INCOHERENT >20°

COHERENT <20°

REFRACTION <1°

X-Ray Source

Object

BALLISTIC 0°
Figure 6. Actual spectrum of projection data in FXCT
[SPIE Regional Mtg. Optoelectr., Photonics, Imaging]
X-ray Diffraction Measurements of Tissues

\[ n_0 \frac{d\sigma}{d\Omega} \text{ (cm}^{-1}) \]

Momentum Transfer \( x \) (Å\(^{-1}\))

TENDON

MUSCLE

x-ray source → specimen → attenuation detector

scatter detector

q(Å⁻¹) = sin(θ/2)/λ

x-ray source → specimen → attenuation detector

energy discriminating scatter detector

q(Å⁻¹) = [E(keV)/12.3] sin(θ/2)
Momentum Transfer Functions - Spectral (---) or Multi-Angular (----)

Nylon

Polycarbonate

Lucite

Water

PCL2000

PCL1250
SOME ALGORITHMS NEEDED TO FULLY UTILIZE SPECTRAL X-RAY IMAGING

1) MODELS TO MITIGATE: ARRAY HETEROGENEITY
                            CHARGE SHARING
                            PHOTON COUNT PILE-UP
                            DETECTOR FLUORESCENCE

2) RECONSTRUCTION ALGORITHMS TO MITIGATE PHOTON-SPARSE SCAN DATA
    -- Use of a priori information
    -- Use of broad spectrum data
    -- Use of region-of-interest scan data
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