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Compton Scatter Imaging for Tumor Tracking - Initial Experiment with a Photon-Counting Detector

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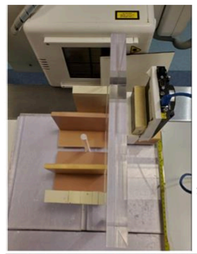
INTRODUCTION/MOTIVATION

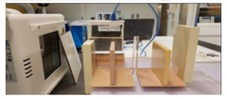
Real time tumor motion tracking is critical for radiation oncology treatment. In this study we tried to explore the feasibility of utilize kV beam Compton scatter for tumor imaging. This approach has been previously studied by the authors (See References). With a high-speed high-sensitivity photon-counting detector (PCD), Compton-scattered x-ray photons were detected through a parallel-hole collimator at the 90-degree direction from the primary beam. The results from this initial experiment demonstrated that additional information can be provided as accurate guidance information for radiation oncology applications.

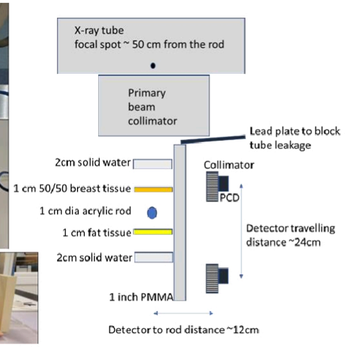
METHOD

The experimental setup was to simulate kV guidance for **lung tumor tracking** scenario. With a clinical radiographic system, the primary beam (120kV 200mAs) was collimated into **a narrow slit (90mm x 5mm)**. **A Cadmium Telluride (CdTe) based PCD (XC-ACTAEON, Direct Conversion)** was used to detect scattered photons at the **90 degree** angle from the primary beam path. The active area of the detector is 25.6 x 25.6 mm^2 with pixel dimensions of 0.1 x 0.1 mm^2. To spatially resolve the detected photons, a parallel-hole collimator, with 25 mm thickness, 1 mm hole size and 0.1 mm lead septa, was placed at the front surface of the detector.

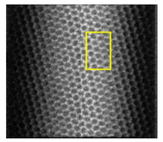
To generate more realistic tissue structures around the chest, different phantom objects were placed along the pathway of the primary and scattered photons, including: **an 1 cm diameter acrylic rod as the targeted tumor, two layers of 2 cm solid water plates as the chest wall, two layers of 1 cm breast tissue equivalent plates, and a uniform 2.5 cm PMMA plate**. The PCD was placed 12 cm from the rod target. Due to its limited view size**, the PCD was translated every 2 cm** (1 cm around the rod) along the primary beam direction to provide full coverage of all the imaging targets.







RESULTS



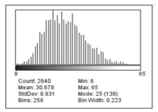
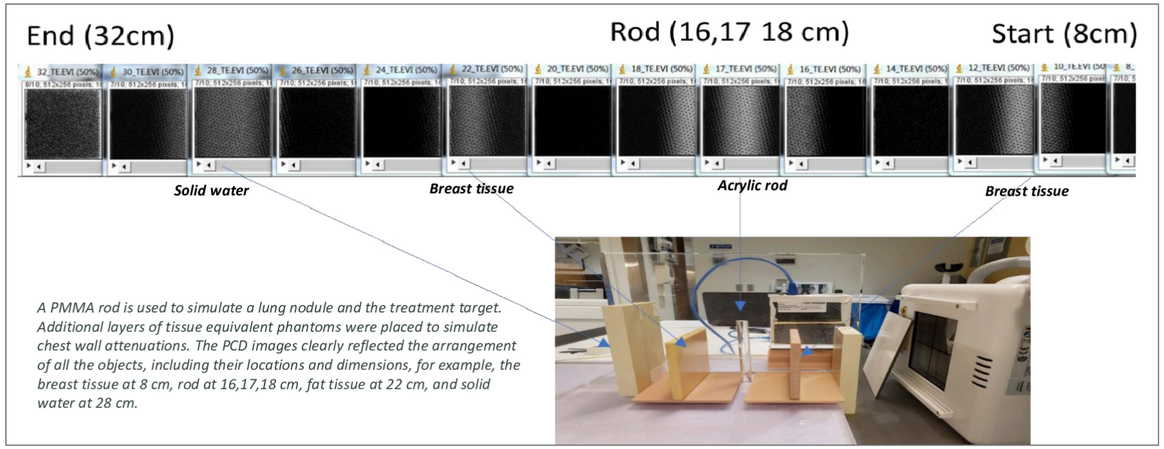


Image on the left *shows one example raw image acquired from PCD. Although the hole structure of the collimator is clearly visible, it does not affect the visualization of the object boundary. The mean photon counts per pixel is ~31 within the selected ROI. Given the small pixel size of the PCD (0.1 mm x 0.1 mm), the detected scatter signal is quite strong.*

The acquired scatter images clearly indicated the locations and dimensions of different objects along the primary beam pathway, including the simulated tumor target. Different tissue types even demonstrated different signal contrast.



A PMMA rod is used to simulate a lung nodule and the treatment target. Additional layers of tissue equivalent phantoms were placed to simulate chest wall attenuations. The PCD images clearly reflected the arrangement of all the objects, including their locations and dimensions, for example, the breast tissue at 8 cm, rod at 16,17,18 cm, fat tissue at 22 cm, and solid water at 28 cm.

Bottom image *shows the final combined image from the total of 14 different PCD locations. The accurate depict of the imaging targets and their relative locations proved the efficacy of this proposed application.*

exp. result (after FFT)

CONCLUSIONS

The results from this study demonstrated that with the high sensitivity of PCD and strong beam collimation, it is quite promising and feasible to utilize 90-degree-scattered photons for imaging guidance purpose.

REFERENCES

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