Purpose: Radioluminescent nanophosphors (RLNPs) show great promise for imaging biological processes in vivo, at the molecular level, and for enhancing the delivery of cytotoxic therapy within the target volume of a radiation treatment. As progress is made towards these goals, there is a need for an imaging modality that can quantitatively measure the distribution of RLNPs in vivo, with high sensitivity and spatial resolution. X-ray luminescence computed tomography (XLCT) is best placed to meet all these requirements. In this scheme, collimated beams of X-ray radiation selectively excite RLNPs, producing optical light within a narrowly-defined volume. Optical measurements of the photons diffusing out of the subject can be interpreted as projective measurements and reconstructed into tomographic images.

Methods: As a proof of concept, we built a prototype XLCT system and acquired projective data for near-IR-emitting RLNPs embedded in various phantoms. A novel reconstruction scheme that includes a model of light propagation in biological tissue was developed and evaluated on XLCT scans with sparse angular sampling.

Results: Imaging in an optically-diffusive medium shows that imaging performance is not affected by optical scatter; furthermore, the linear response of the reconstructed images suggests that XLCT is capable of quantitative imaging. Reconstruction that combines models of light and X-ray propagation in tissue was found more accurate for sparsely-sampled datasets.

Conclusion: Based on phantom experiments, we found XLCT to be a feasible approach for imaging RLNPs tomographically. As we advance towards our goal of imaging RLNPs in live animals, we are designing and building a new imaging set-up with improved X-ray collimation and light collection efficiency.