Purpose: To demonstrate the feasibility of determining the location and gold concentration of gold nanoparticle (GNP)-loaded regions within polymethyl methacrylate (PMMA) phantoms using cone-beam polychromatic x-ray fluorescence computed tomography (XFCT) technique.

Methods: Tubes containing water and GNPs at 2%, 1%, and 0.5% by weight were inserted into two 5 cm-long cylindrical PMMA phantoms with 3 cm and 5 cm in diameter, respectively. The phantoms were irradiated by a cone-beam of polychromatic 110 kVp x-rays filtered by 1.0 mm of lead. Energy-sensitive cadmium telluride detectors behind a 2.5 mm diameter lead pinhole collimator collected the spectrum of emitted gold K-shell fluorescence and Compton scattered photons at an angle of 90º relative to the beam central axis as the phantom was rotated to a series of 60 projection angles in 6º steps. Sinograms of gold fluorescence photon signals were constructed by extracting the gold fluorescence peak height from the Compton background, and the image of GNP location and concentration was reconstructed using a maximum likelihood iterative reconstruction algorithm.

Results: Using the measured sinograms, images of GNP location were successfully reconstructed for both the 3 cm and 5 cm phantoms. Additionally, the signal intensity was linearly related to gold concentration. The x-ray dose delivered during the XFCT scanning was measured using the TG-61 protocol, and it was determined that, using an array detector, it would be possible to acquire these images with roughly 30 cGy of x-ray dose delivered.

Conclusions: This study demonstrates, for the first time to our knowledge, the feasibility of imaging GNP location and concentration within small animal-sized objects using an ordinary cone-beam polychromatic x-ray source under realistic constraints on dose and scan time. This investigation strongly suggests a bench-top XFCT system will ultimately become a viable option for in-vivo molecular imaging with conjugated or unconjugated GNPs.