

Purpose: To develop a novel X-ray stimulated fluorescence (XSF) system for molecular imaging of breast cancer. This new paradigm, used in conjunction with bioconjugated gold nanoparticle (AuNP) imaging agents targeted to breast cancer, will enable molecular imaging with X-ray selective excitation. These targeted AuNP can emit XSF (a.k.a characteristic X-ray) photons when excited with a sheet-beam X-ray, thereby producing a molecular imaging contrast and providing improved lesion conspicuity.

Methods: The novel imaging mechanism used in XSF system consists in selectively irradiating a single slice through the breast using a sheet-collimated X-ray beam, while an ultrahigh resolution dual-headed pixilated photon counting detector measures the XSF coming out of the selected slice. The breast can be positioned directly on the dual-headed planes, and, consequentially, spatial resolution is improved with less distance between breast lesions and the detectors. The transmission X-ray photons (anatomical image) will be also collected simultaneously with another X-ray photon detector in this imaging geometry. Simulations of an XSF system were performed using a Monte Carlo simulation software GEANT4 (CERN). A preliminary experiment with physical phantoms was also conducted using a superficial treatment beam and a photon counting detector.

Results: With this design, 1-D slice spatial information can be obtained via selective excitation with a sheet X-ray beam (a mechanism similar to the slice selection in MRI). Meanwhile, the dual-headed pixilated detector localizes the origin of each detected XSF photon to a distinct voxel in the breast, thus providing complementary 2-D information. As such, this imaging geometry provides 3-D mapping of the precise location of lesions without the need for rotating the gantry during the acquisition procedure or tomographic reconstruction.

Conclusions: The proposed molecular imaging approach represents a paradigm shift in X-ray breast imaging, which may enable breast cancer detection at the cellular and molecular level.