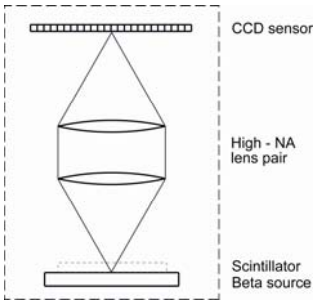
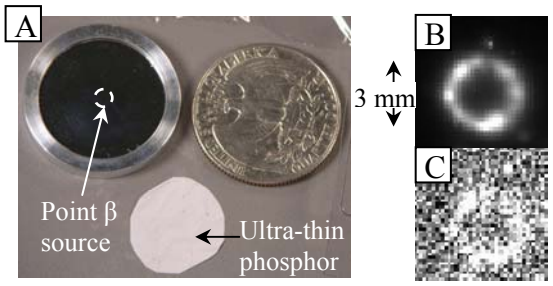
High-resolution High-Sensitivity Electron Imager



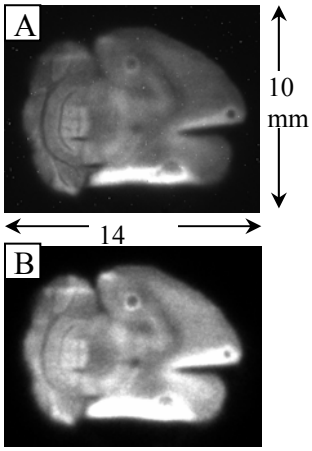
Schematic diagram of the electron imaging system.

A new method has been invented to directly image the distribution of electron-emitting isotopes at very high resolution and sensitivity, which will benefit microdosimetry studies of radiopharmaceuticals, especially beta-emitting therapeutic drugs. The method uses an ultra-thin phosphor, a monolayer of 3-μm P47 phosphor powder deposited on 3-μm clear Mylar foil, layered on radioactive objects to convert the kinetic energy of emitted electrons into light, which is then coupled to a digital light sensor by optical coupling means. The images of the fluorescent light patterns represent the isotope distributions under study. Our group at the Center for Gamma-Ray Imaging has completed a proof-of-concept prototype system using a large-area low-noise CCD detector and various large-aperture imaging lenses. When using optics at unit magnification, the system has resolved the actual annular shape of a 3-mm 100-nCi Y-90/Sr-90 β source, ostensibly a point source. From the images, the spatial resolution is measured at 60 μm, and the detection limit of this source is about 185 disintegrations.

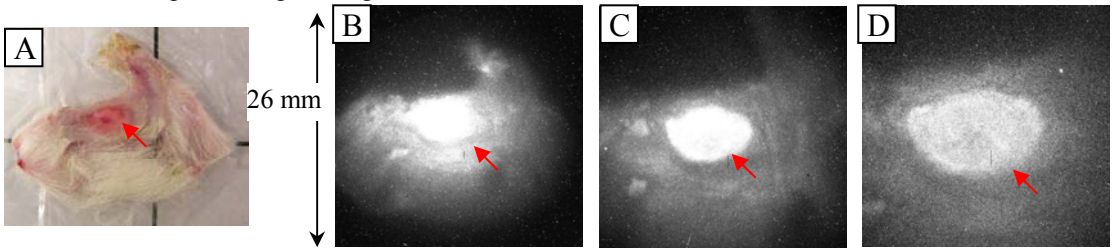


Photograph of the phosphor and the β source (A), the electron images of the source at 5-min (B), and 0.1-sec (C) exposures.

Besides β emissions, the system is also very sensitive to other charged particles such as positrons and conversion electrons from γ emitters. When imaging samples *in vitro*, our system at unit magnification can provide similar spatial resolution, sensitivity, and linear response range to state-of-art digital autoradiography systems using storage phosphors. The resolution is improved further with optics at higher magnifications.



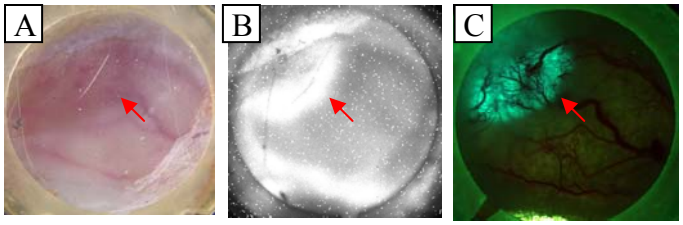
18-F-FDG uptake in a mouse brain slice by our system (A) and digital autoradiography (B)



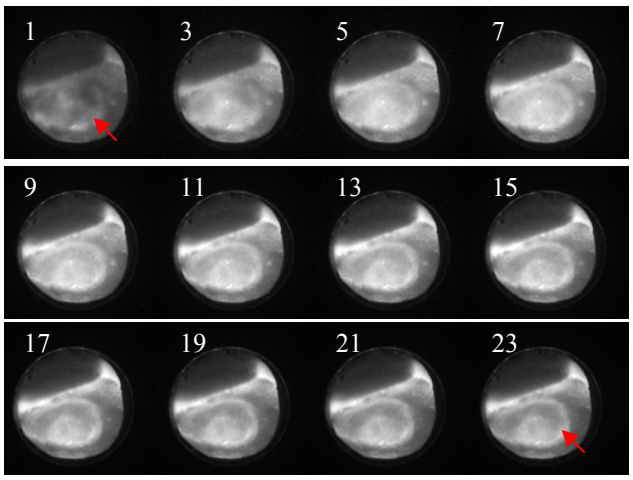
A mouse was implanted subcutaneously with a breast tumor and later injected with Tc-99m-labeled ECDG before euthanization. Photograph of the mouse skin tissue with the cancer (A), and the images of the conversion electron emissions from the tissue at 1X (B), 1.7X (C), and 2.7X (D).

Unlike autoradiography, our system is capable of imaging small animals *in vivo*. Our group has used the system to image *in vivo* the 18-F-FDG uptakes in 3 types of tumors implanted in dorsal skin chamber on 3 mice respectively. The images also showed the heterogeneity of FDG distribution inside a tumor about 5 mm in spatial dimension. Due to the high sensitivity of the system, we also demonstrated the dynamic imaging of the 18-F-FDG uptake in tumor during a 1-hour period.

The concept of the electron imaging will debut at the 54th Annual Meeting of the Society of Nuclear Medicine in summer 2007. Even before the official disclosure, this system has attracted much attention from all over the world.



Photograph of an 18-F-FDG labeled GFP transfected tumor in dorsal skin chamber (A), its positron image (B) and fluorescence image (C).



Positron image (2-minute exposure and 35 seconds readout time) sequence of an 18-F-FDG labeled tumor in dorsal skin chamber in over an hour.

1. L. Chen, L. S. Gobar, G. D. Stevenson, A. F. Gmitro, and H. H. Barrett, Electron imaging system using ultra-thin phosphor film and CCD camera for *in vivo* imaging, Under review, Society of Nuclear Medicine 54th Annual Meeting, Washington DC, 2007.
2. L. S. Gobar, L. Chen, and H. H. Barrett, Evaluation of a digital autoradiography system based on ultra-thin phosphors and a CCD camera, Under review, Society of Nuclear Medicine 54th Annual Meeting, Washington DC, 2007.