Quantitative Single-Particle Digital Autoradiography with the Ionizing-Radiation Quantum Imaging Detector

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Presented is a novel digital autoradiography camera and imaging methodology called iQID (ionizing-radiation Quantum Imaging Detector). The imager comprises a scintillator in direct contact with a micro-channel plate (MCP) image intensifier and a lens for imaging the intensifier screen on to a CCD or CMOS camera sensor, all within a compact light-tight enclosure. iQID is sensitive to a broad range of radiation including gamma-/X-rays, neutrons, spontaneous fission, conversion electrons, alpha and beta particles. Individual photons or particles absorbed in the scintillator crystal or phosphor screen produce a flash of light that is amplified via the image intensifier by a factor of 10^4–10^6 and then imaged on to the camera. Scintillation flashes associated with individual events are finely sampled with an array of pixels and referred to as an event cluster. iQID's ability to localize charged particles, both spatially and temporally, on an event-by-event basis enables alpha-particle radioactivity distributions to be quantified at millibecquerel-levels in small volumes, e.g., 10 × 10 × 10 μm^3, even with short-lived isotopes. Images are constructed in real time at high spatial resolutions with an unrestricted dynamic range. The intrinsic spatial resolution of the detector has been measured to levels as high as 20 μm with alphas. iQID is a portable, laptop-operated system that requires no cooling and leverages the ever-increasing advances in CCD and CMOS camera sensor technology. The most recent system developed uses a 4-megapixel camera (2048 × 2048 pixels) that acquires full-resolution images at rates up to 90 frames per second. Large-area iQID configurations (up to 200 mm diameter) accommodate autoradiography studies requiring simultaneous imaging of an array of tissue sections. An overview of the technology and recent imaging studies with alpha (^{239}Pu, ^{241}Am, ^{226}Ra, ^{232}Th, and ^{211}At) and beta emitters (^{90}Y and ^{177}Lu) will be presented that demonstrate the application of iQID as an integral imaging tool for radiobiology applications and microdosimetry in targeted radionuclide therapy.

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