Prospects for Two-Dimensional Brachytherapy Dosimetry using Plastic Scintillator: Signal-to-Noise Ratio and System Design Considerations

Plastic scintillator (PS) is a promising dosimeter for brachytherapy because of its high sensitivity, approximate tissue equivalence and potential for simultaneous high-resolution dose measurement everywhere in the 2D detector plane. We have developed a prototype 2D dosimetry system using a liquid nitrogen-cooled CCD camera with a 512x512 detector array. For a 1 mm thick BC-400 scintillator sheet near a model 6702 I-125 seed (S_K = 30 U), repeated measurements were performed to quantify signal-to-noise ratio, SNR^{-1}, as the %standard deviation, σ, relative to the mean net counts, μ, for each pixel. By modeling $100\%(\sigma/\mu)$'s dependence on count rate and integration time, total single-pixel noise was decomposed into its Poisson photon counting, time-dependent background and stationary background components. For dose rates and data acquisition times above 50 cGy/h and 60 s, system precision is limited by Poisson counting statistics, showing that ±2% precision for Cs-137 LDR sources is possible for integration times under 300 s. By improving sensitivity 100-500-fold (achievable by merging pixels, increasing photon collection efficiency, and using water equivalent scintillator), dose rates of ≅0.2 cGy/h should be measurable in 300 s with ±2-3% precision, demonstrating the feasibility of I-125 dose measurements. Comparison of measured 2D I-125 optical scintillation images with corresponding 2D Monte Carlo calculations, shows good agreement.
This work was supported by NIH Grant R01 CA 57222.