Developing a Directional High-Dose Rate Brachytherapy Source

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Conventional sources used in brachytherapy provide nearly isotropic or radially symmetric dose distributions. Optimizations of dose distributions have been limited to varied dwell times at specified locations within a given treatment volume, or manipulations in source position for seed implantation techniques. In years past, intensity modulated brachytherapy (IMBT) has been used to reduce the amount of radiation to surrounding sensitive structures in select intracavitary cases by adding space or partial shields.

Previous work done by Lin et al., at the University of Wisconsin-Madison, has shown potential improvements in conformality for brachytherapy treatments using a directionally shielded low dose rate (LDR) source for treatments in breast and prostate.

Directional brachytherapy sources irradiate approximately half of the radial angles around the source, and adequately shield a quarter of the radial angles on the opposite side, with sharp gradient zones between the treated half and shielded quarter. With internally shielded sources, the radiation can be preferentially emitted in such a way as to reduce toxicities in surrounding critical organs.

The objective of this work is to present findings obtained in the development of a new directional high dose rate (d-HDR) source. To this goal, ^{103}Pd (Z = 46) is reintroduced as a potential radionuclide for use in HDR brachytherapy. ^{103}Pd has a low average photon energy (21 keV) and relatively short half -life (17 days), which is why it has historically been used in low dose rate applications and implantation techniques. ^{103}Pd has a carrier-free specific activity of 75000 Ci/g. Using cyclotron produced ^{103}Pd, near carrier-free specific activities can be achieved, providing suitability for high dose rate applications.

The evolution of the d-HDR source using Monte Carlo simulations is presented, along with dosimetric parameters used to fully characterize the source. In addition, a discussion on how to obtain elemental palladium, Pd(0), will be discussed in detail. Directional HDR has the potential to improve upon current treatments, providing better dose conformality to the target volume, while maintaining the benefits of HDR applications.