Advanced methods for quality assurance and dose distribution improvement for high dose rate brachytherapy

Summary

Brachytherapy is a method of radiotherapy that consists on placing a radioactive source in close contact or inside the tumor, resulting in a steep gradient on the dose distribution, which helps protecting organs at risk but also makes the technique prone to errors in case of wrong positioning of the radioactive source. There are several stages involved in a treatment workflow, from afterloader commissioning to treatment delivery and verification. In this thesis, several stages of a brachytherapy treatment were evaluated as part of an effort to improve accuracy and precision of dose delivery.

The viability to 3D tracking a brachytherapy source using an imaging panel was shown possible by applying a 2D gaussian fit to the panel response to locate the source and the distance between the source and the panel could be determined considering the gaussian shape. The same principle was adopted in a quality assurance system for brachytherapy applicators that uses an ^{192}Ir source to acquire a projection of the applicator into the imaging panel and then sends the source inside the applicator to track its movement with submillimeter precision.

The main focus of this thesis, however, was to develop an applicator for rectal cancer capable of generating a dose distribution similar to those generated by 50 kVp x-ray devices, but using HDR ^{192}Ir sources. The applicator was successfully modeled by using the inverse square law to achieve a steep dose falloff by bringing the ^{192}Ir source at several points in close contact to the treatment surface.

Finally, a new afterloading system was thoroughly evaluated using multiple quality assurance devices, high speed camera and imaging panel to verify current limitations in brachytherapy dose delivery due to precision and accuracy of dwell times, dwell positions and transit dose effects.

Keywords: brachytherapy, Monte Carlo, dosimetry, commissioning