

Introduction

Clinical dosimetry in brachytherapy is performed according to the AAPM TG-43 formalism[1], treating the patient entirely as water with infinite scattering medium. RapidBrachyMCTPS is an open-source treatment planning system for brachytherapy based upon a Monte Carlo (MC) dose calculation engine[2,3]. Dose to patient medium is determined using radiation transport simulations in a reconstruction of the patient with accurate assignment of material composition and density. However, dose to water, as specified by TG-43, for a treatment plan is often desirable for simplicity and comparability to clinical dose calculations, but currently must be obtained using a full MC simulation. This work aims to develop and benchmark (1) a MC-based software framework that interfaces with RapidBrachyMCTPS for TG-43 parameter characterization of sources and (2) enable TG-43 parameter-based dose calculation and optimization in RapidBrachyMCTPS.

Materials and Methods

RapidBrachyTG43 was developed as a module of RapidBrachyMCTPS. It features GUI elements to prepare MC simulations for TG-43 parameter calculations for a source, and automatically process dose maps into TG-43 parameters. The MC engine uses simulations in Geant4 v. 11.1 to determine the necessary air kerma and water dose distributions for TG-43 parameter calculations. Radioactive decay is simulated explicitly, allowing for characterization of novel brachytherapy sources without needing precalculated source spectra. RapidBrachyTG43-calculated or other TG-43 parameter datasets may then be imported by the module to perform a dose calculation for a treatment plan created in RapidBrachyMCTPS.

TG-43 parameter calculations were benchmarked by comparison to the Carleton Laboratory for Radiotherapy Physics (CLRP) Brachytherapy TG-43 Parameter Database for Brachytherapy datasets generated with egs_brachy for three sources: SelectSeed (¹²⁵I), microSelectron-v2 (¹⁹²Ir), and A86 (⁶⁰Co). TG-43 dose calculations were benchmarked by comparison with RapidBrachyMCTPS's Geant4-based dose calculation engine for a clinical breast plan with all voxels set to water.

Results

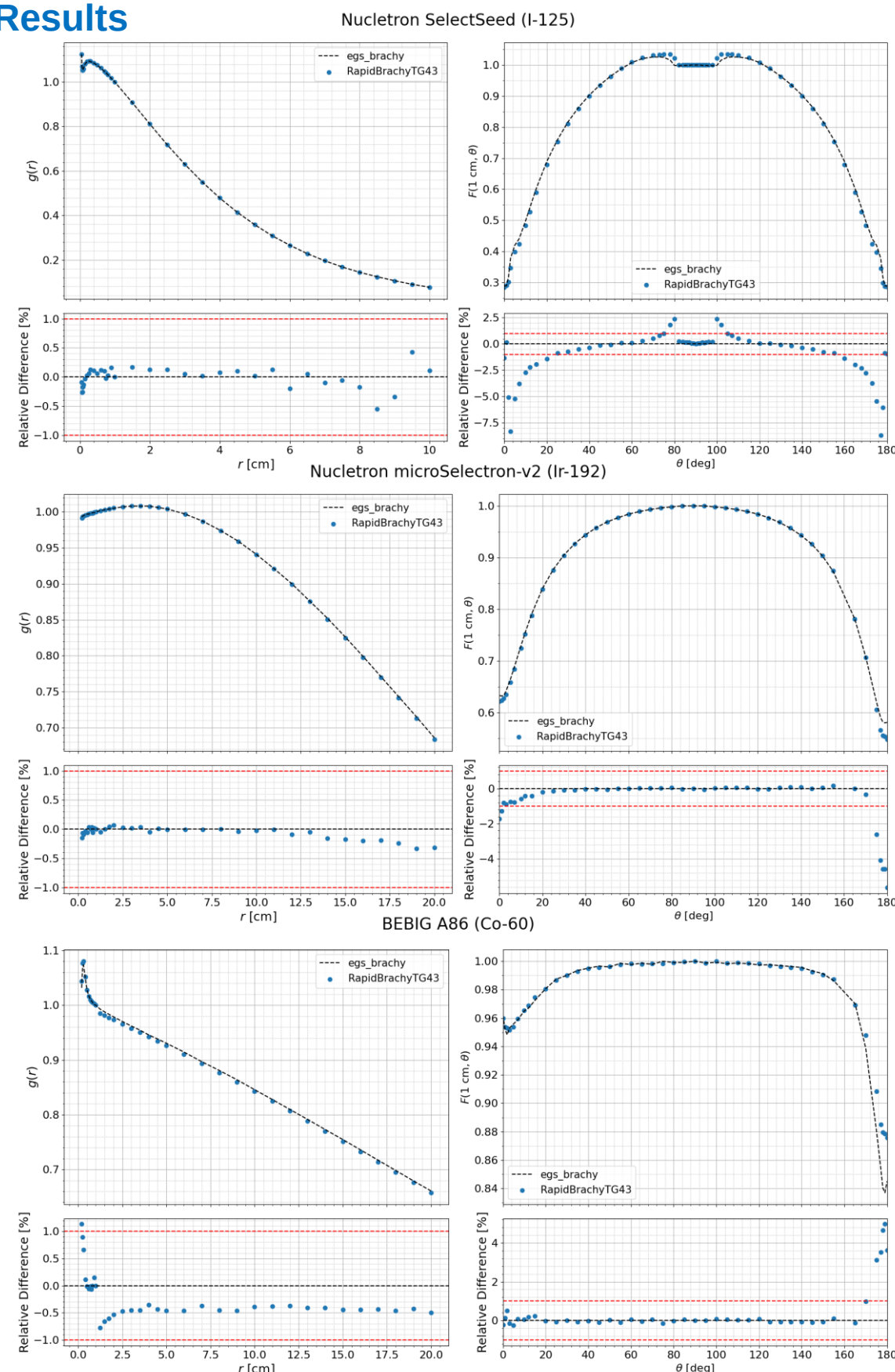


Figure 1. Comparisons for radial dose function and 2D anisotropy function evaluated at 1 cm between RapidBrachyTG43 and CLRP database version 2 TG-43 datasets for three commercial source models.

Metric	TG-43		MC	%diff
	Full	Body Only		
PTV D90 [Gy]	3.619		3.644	0.7
Heart D2cc [Gy]	1.458		1.454	0.3
Chest Wall D2cc [Gy]	2.659		2.675	0.6
Skin D2cc [Gy]	2.756	2.731	2.772	0.6, 1.5
Calculation Time [s]	165	40	8416	-
Gamma Pass Rate, 1%/1 mm	99.3%			

Figure 2. Comparison of metrics from the TG-43 vs MC dose to water calculation; 'Body Only' corresponds to a setting restricting dose calculation only to voxels inside the body contour.

Conclusion

Calculations of TG-43 parameters and dose have been enabled in the GUI of RapidBrachyMCTPS, and each agreed to benchmark data within tolerance. Dosimetry parameters for existing and novel source models and isotopes can be determined accurately with minimal user input and no manual configuration of simulations. Water dose-based optimization of treatment plans using the TG-43 formalism in lieu of MC simulations is now available in RapidBrachyMCTPS.

References

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- Famulari, Gabriel, et al. "RapidBrachyMCTPS: a Monte Carlo-based treatment planning system for brachytherapy applications." Physics in Medicine & Biology 63.17 (2018): 175007.
- Glickman, Harry, et al. "RapidBrachyMCTPS 2.0: a comprehensive and flexible Monte Carlo-based treatment planning system for brachytherapy applications." arXiv preprint arXiv:2007.02902 (2020).

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