

AbstractID: 3590 Title: Equivalent stochastic dose (ESD): Quantifying the impact of dose uncertainties on radiotherapy treatment plans

Purpose: To study the impact of dose uncertainties on radiotherapy treatment plans through the use of survival fraction.

Method and Materials: We considered the case, where the total dose to a volume element has an associated uncertainty. To distinguish between spatial and probabilistic dose heterogeneities, we define *equivalent stochastic dose* (ESD) as the dose that results in a mean survival fraction for a randomly deposited dose to a volume. For a probability density function, $f(D)$, that represents the dose to a voxel, $SF(ESD)$ can be calculated using the convolution technique. In the case where the probability density function follows a Gaussian distribution, an analytic expression has been derived for $SF(ESD)$. The expression has been verified using the Monte Carlo method for various radiosensitivities and α/β ratios.

Results: The results show that survival fraction increases with an increased dose uncertainty and was found to be dependent on the radiobiological parameters. Using the analytic expression for $SF(ESD)$, dose uncertainty can be evaluated for any voxel or group of voxels in the dose matrix, including those in an OAR and/or PTV. For spatially Gaussian dose distributions a statistical uncertainty of 2% was found to result in an average *equivalent uniform stochastic dose* (EUSD) of 98% with respect to the modelled mean dose. As the dose uncertainty increased beyond 5% the ratio of EUSD to prescribed dose dropped rapidly.

Conclusion: In this work, statistical and physical dose uncertainties have been combined in a formalism that concurrently quantifies the impact of each on survival fraction. The effect of dose uncertainty can easily be evaluated for any voxel in the dose matrix including the PTV and OAR volumes. This can be useful in the assessment of planned treatments when dose uncertainty estimates are known.