AbstractID: 11200 Title: Influence of CT image noise on proton range uncertainty

Purpose: To evaluate the uncertainty of computed proton range in radiotherapy treatment planning which is attributed to random component in CT numbers**.**
Method and Materials: We utilize a random number generator to simulate a white Gaussian noise in CT numbers along the proton pathlength. The proton range is computed using continuous slowing down approximation which is valid for most of proton range. To simulate the statistical straggling of computed proton range, this procedure is iteratively repeated to obtain convergence of proton range PDF which is approaching a Gaussian. The FWHM (full-width at half maximum) of the range PDF is used as a measure of uncertainty.
Results: We investigate parameters which affect the proton range uncertainty in the presence of CT image noise. These parameters may include 1) initial proton energy, 2) noise period and 3) noise amplitude. The FWHM of range PDF increases linearly with the noise period. These results indicate that low frequency fluctuations in CT image noise can significantly increase the range uncertainty. We have also computed the range PDF as a function of initial proton energy. The FWHM of range PDF increases linearly with the initial proton energy. For the maximum proton energy of 250 MeV, the FWHM of proton range PDF can achieve a value of 5 mm in the presence of CT image noise. We note that the ratio FWHM/range increases as the proton range decreases; therefore, the relative range uncertainty is larger for smaller ranges.
Conclusions: Range uncertainties due to CT image noise can be significant and comparable to the uncertainties attributed to the calibration of CT numbers. The relative range uncertainty increases as the range decreases. Noise reduction in CT images using smoothing and denoising algorithms can be recommended to reduce the standard deviation of range PDF.