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# Proton therapy x-ray CT calibration by proton tomography

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**Purpose:** The dose computation in the proton treatment planning system (TPS) is based on the proton relative stopping power normalized to liquid water (RSP) distribution in the target volume. Presently, the RSP maps are extracted from x-ray computed tomographies (xCT) of the patient. Namely, the photon attenuation coefficients (CT Hounsfield Units –HU), are translated into RSP values using empirical methods based on conversion tables. These methods introduce an uncertainty on the actual position of the Bragg peak inside the patient [1], which has to be mitigated by means of the use of safety margins around the target and organs at risk. To avoid this two-step process and to reduce the intrinsic errors, we propose a different approach based on the direct use of 3D RSP maps obtained with a proton computed tomography (pCT) system. Recently, a pCT system has been developed in the framework of *INFN*-funded research projects [2].

**Methods:** The pCT system has been tested at the *Trento Proton Therapy Center*. At first, we implemented a custom-built phantom made of five different synthetic cylindrical inserts, to probe the performance parameters, i.e. spatial resolution, accuracy and noise spectrum. A filtered backprojection algorithm, taking into account the protons'most likely path, allowed reconstructing the phantoms'RSP 3D maps [3]. Then, pCT and xCT were acquired on a biological phantom (bovine specimen) stabilized with a formalin solution and embedded agar-agar gel. The direct, voxel-by-voxel comparison of HU and RSP maps of the biological phantom provides a cross-calibrated xCT calibration curve, i.e. a SPR-HUs look-up table, improving the description provided by the existing calibration methods.

**Results:** According to preliminary analysis, a resolution of about 0.65 lp/mm was estimated. Direct measurements of RSP values of the cylindrical inserts showed a mean absolute percentage error of 0.7% and a minimum obtainable noise magnitude of about 0.005 for RSP. Finally, we obtained a preliminary cross-calibration curve through the biological phantom tomographies.

**Conclusions:** After the performance characterization of our pCT apparatus, we constructed a preliminary HU-RSP calibration curve through the direct comparison of xCT and pCT images of a stabilized biological phantom. Then, the cross-calibration procedure will be verified on TPS in comparison with the standard CT calibration, aiming at reducing the impact of range-related uncertainties, thus improving the dose computation accuracy in proton therapy.

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