

Purpose: Water-to-air stopping power ratio ($S_{w,air}$) is currently known with an uncertainty of 2% for carbon ion beams (IAEA's TRS-398), and it is the main source of uncertainty in absolute dosimetry with air-filled ionization chambers. We present here a more precise calculation of its value from measurements performed under controlled experimental conditions.

Methods: $S_{w,air}$ is given in TRS-398 as a particle fluence weighted average over all particles and energies, and it is derived from track-length fluence of each particle in water and its mass stopping powers in water and air. All these quantities were calculated with the general-purpose Monte Carlo code FLUKA. The input values to the code, including water and air mean ionization potentials of $I_w = 75.9 \pm 0.2$ eV and $I_{air} = 87 \pm 3$ eV, were chosen in accordance to experimental measurements of mono-energetic carbon ion beams carried out at the Heidelberg Ion Therapy Center (HIT). The $S_{w,air}$ was calculated for spread-out Bragg Peaks (SOBPs) at different depths, and a possible dependence on the residual range was investigated.

Results: For all the studied SOBPs, the uncertainty in the stopping power ratio could be reduced significantly by introducing a logarithmic dependence on the residual range. Moreover, using the fixed value of $S_{w,air} = 1.13$ causes, on average, a dose underestimation of 0.1 % if used in the plateau area and of 0.4% if used in the peak (compared to Monte Carlo data), whereas using our $S_{w,air}(z)$ model reduces this dose underestimation below 0.05% in all cases.

Conclusions: The contribution presents a revised calculation of the water-to-air stopping power ratio using own experimental data that reduces significantly the uncertainty of the current reference value.

Funding Support, Disclosures, and Conflict of Interest:

The research leading to these results has received funding from the European Community's Seventh Framework Programme 2007-2013 under grant agreement n° 215840-2 (PARTNER).