A novel cylindrical 3D water scanner for beam data collection: I. Validation of the automatic-setup.

**Innovation/Impact:** We validated the accuracy and reproducibility of the automatic-setup procedure of a novel cylindrical 3D water scanner. The automatic setup of the scanner makes beam data collection less user dependent.

**Purpose:** To determine the accuracy and reproducibility of the automatic-setup procedure of a commercial three-dimensional water scanner used for beam data collection (3D SCANNER, Sun Nuclear Corp., Melbourne, FL). The novel cylindrical water tank was designed to ensure a consistent detector orientation to profile acquisition (in-plane, cross-plane, angular). This is achieved by mounting the horizontal scan axis on a ring, which rotates to any desired angle. Also, a unique off-center detector holder extends the scan range from 500 mm to 630 mm, eliminating the need for scanner shifts for large-field scans.

**Methods:** The automatic-setup procedure provides means to automatically: (1) level the tank; (2) zero the detector position to the water surface; (3) align the 3D SCANNER’s coordinate system to the LINAC’s coordinate system; and (4) correct the motor hysteresis. After automatic-setup, the water surface and chamber horizontal movement parallel to water surface were evaluated visually by three experienced physicists as either “acceptable” or “need adjustment”. Item (3) was tested by moving one of the jaws to the isocenter to create a half-beam blocked field and in-plane/cross-plane scans were made along the jaw edge. Angular misalignment between the jaw edge and chamber movement direction would result in a noticeably tilted profile. To test the mechanical reproducibility and the accuracy of hysteresis correction, ten cross-plane scans were done with the chamber moving back and forth. Finally, the accuracy of the off-center detector holder was tested by comparing scans made using the regular and the off-center detector holders. Any field width difference would indicate error in the ring center determination. All tests were performed three times (i.e., three independent automatic-setup procedures) using an Elekta Synergy linac with 6 MV photon beam.

**Results:** All tests of the water surface and horizontal chamber movement parallel to water surface resulted in an “acceptable” verdict from the nine independent evaluations. The profile scans along the jaw edge resulted in less than 1% in profile tilt over the central 20 cm scan length (Fig 1), corresponding to less than 0.05° angle between the jaw edge and chamber travel direction. Field edge difference for repeated cross-plane scans when the chamber was moved in the same direction was less than 0.05 mm, and less than 0.2 mm when the chamber was moved in the reverse direction (Fig 2). There is no difference in positional accuracy when using the default scan speed (5 mm/s) and when the fast scan speed (8 mm/s) was used. Comparison of profiles obtained using the regular and the off-center detector holders resulted in less than 0.2% difference within 80% of the field size and less than 0.2 mm difference in beam edge. Fig 3 shows a cross-plane profile of a 40x40 cm² open field using the off-center detector holder, without offsetting the tank position. Total automatic-setup procedure took about 25 minutes.

**Conclusion:** The automatic-setup procedure resulted in accurate determination of the water surface, tank leveling, and alignment with the LINAC’s major axes. It produced consistent setup and would minimize the variability among different users. The system is compact and easy to setup with no ion chamber extension cables to deal with. It provides the ability to scan large field size profiles (including diagonal profiles) in their entirety without the need to offset or change tank setup. The dosimetric characteristics of the system will be presented in a separate study.