A 27 × 27 ion chamber array, the Seven29 (PTW, Freiburg, Germany), was used in this study to measure the dose distribution and to provide an independent verification method for VMAT treatment plans. The Seven29 was sandwiched between two 10-cm thick 30 × 30 cm² plastic water slabs and placed in sagittal or coronal orientations on the treatment couch (Figure 1). The center of the array was positioned at isocenter for these experiments. To correct for observed under-response of the Seven29 to irradiation from the back surface of the Seven29 assembly, a 1-cm thick cylindrical half-shell structure was inserted in the backside 10 cm plastic water in the treatment planning system (TPS) (as shown in Figure 2) and a high Hounsfield unit (HU) value of 2000 was assigned to it, as an alternative tactic to the use of an 2-cm thick air cavity as in the PTW Octavius phantom (Van Esch et al 2007).

The directional response of the Seven29 (in a sagittal orientation) was measured for the 10 x 10 cm² field irradiated from different gantry angles and energies. Figure 3 illustrates the central axis results of 6MV, 10MV, 15MV, 6MV flattening filter free (FFF) and 10MV FFF photon beams. The differences between the measurements and the TPS calculations are within 2.8% for all angles and energies. The maximum discrepancies of 2.8% were found at the gantry angle where beam axis is parallel to the plane of the ion chamber array, where the TPS calculation is least accurate with beam penetrating through many detectors. Off-axis dose verifications were performed using gamma index figure of merit (Low et al 1998) with the conventional criteria of 3 mm distance-to-agreement (DTA) and 3% relative dose difference (DD) between calculated/measured plans. All gantry angles and energies passed the test of 90% of detectors having gamma<1.

Half-arc open field treatment of 5x5 cm² and 10x10 cm² field sizes for all available TrueBeam photon energies were measured. Figure 4 illustrates dose profiles of all half-arc deliveries. The maximum difference at the central axis is
1.9% for the 10 MV FFF beam with 5x5 cm² field size. The off-axis dose verification passed the 90% gamma index test (3%, 3mm) for all beam energies.

Figure 4. Measured and calculated profiles of half-arcs, 10x10 cm² and 5x5 cm² field sizes, for all TrueBeam energies.

Typical results of a patient-specific QA measurement are illustrated in Figure 5. For the measurements with Seven29 in sagittal and coronal orientations, the gamma tests (3%, 3mm) pass rates are 95.3% and 99.7%, respectively.

Figure 5. Typical results of a patient-specific QA measurement including calculated (left) and measured (middle) dose distributions and gamma index histogram (right) for the Seven29 in coronal (a) and sagittal (b) orientations.

The developed procedure for patient-specific QA was tested on patient plans using the Seven29 in both coronal and sagittal orientations. For the dose distribution verification of VMAT plans, the Seven29 2D ion chamber array provides overall accurate measurement results. The combination of Seven29 with plastic water phantom proved to be a fast and reliable tool for QA of VMAT treatments. Through this characterization of its directional response, accurate orthogonal 2D dose maps can be generated for independent verification of the treatment delivery from complex VMAT plans.

Reference: