Clinical Note

Beam Quality Verification Using IC PROFILER™ with Quad Wedge Accessories

Performing beam quality verification with an ion chamber in (solid) water is time-consuming and laborious, requiring multiple trips into the vault for each energy.

As an alternative, an attenuating object of varying thickness, such as a wedge, can be placed into the field, and variation in beam quality can then be deduced from attenuation changes. This clinical note explores this approach.

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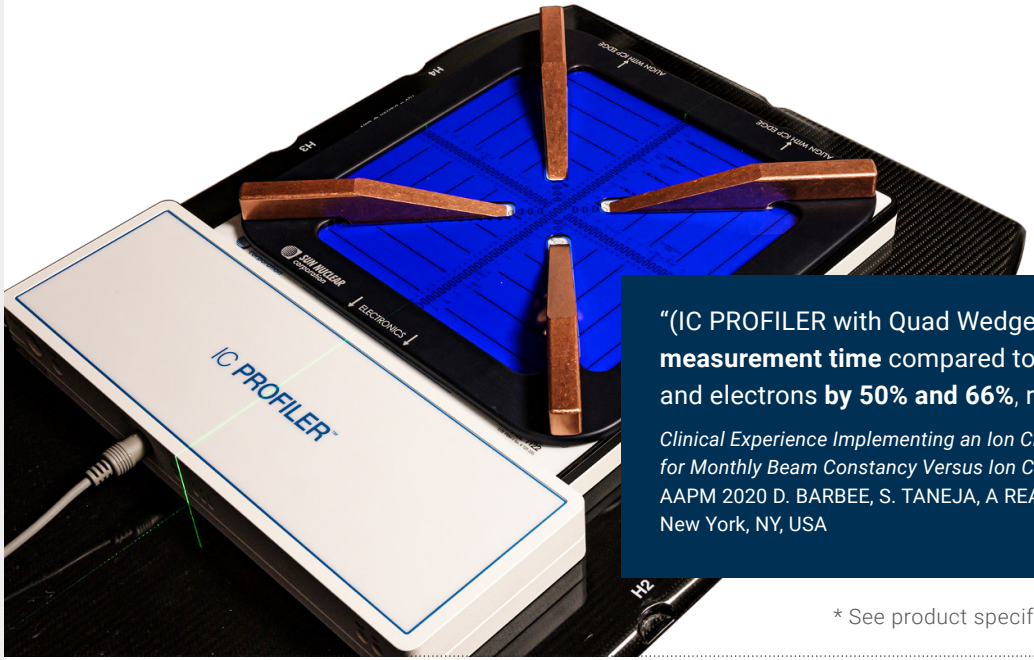
Background

The standard approach to beam quality determination is the measurement of depth dose curves using an ion chamber in (solid) water. In order to reduce the required time, effort and possibility of errors, a major linac manufacturer approached Sun Nuclear to develop a solution that could replace a specialized water tank used to tune beams during install.

To be viable, the solution needed to provide water equivalent beam quality results for flattened and un-flattened (FFF) beams. This was achieved with the Quad Wedge accessories, used in conjunction with the IC PROFILER. Quad Wedge accessories feature a copper wedge plate for photon beam measurements and an aluminum wedge plate for electron beam measurements which:

- Greatly simplify the process
- Significantly reduce time commitment

This solution is now available for clinical use on most linear accelerators.* With well-researched and proven water equivalent results across a wide range of delivery systems and clinical energies, medical physicists can have confidence adjusting beams without the need for a water tank.



"(IC PROFILER with Quad Wedges) **reduced overall measurement time** compared to FCW for photons and electrons **by 50% and 66%**, respectively."

Clinical Experience Implementing an Ion Chamber Array for Monthly Beam Constancy Versus Ion Chamber in Water;
AAPM 2020 D. BARBEE, S. TANEJA, A REA; NYU Langone Health, New York, NY, USA

* See product specifications for details

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Equipment and Methods

IC PROFILER

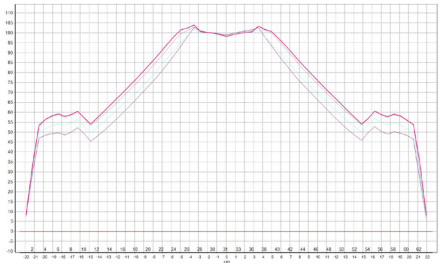
- 251 ion chambers arranged in four linear arrays – X axis, Y axis, and two diagonal arrays
- 0.046cm^3 active volume
- 32cm span with 0.5cm detector spacing on principal (X and Y) axes
- 45cm span with 0.7cm detector spacing on diagonal axes

Quad Wedge Plates

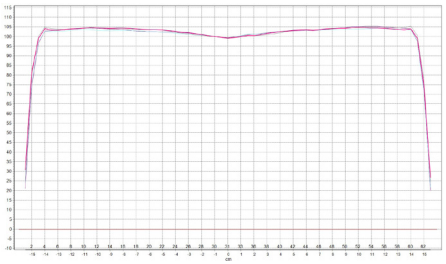
- Four metal (copper or aluminum) wedges fixed in aluminum frame, mounted on acrylic plate with 0.3cm thickness
- Designed to align flush with edges of IC PROFILER for easy positioning
- Maximum water-equivalent buildup is 23.9cm for copper wedges, and 8.1cm for aluminum wedges

Results

Wedged Diagonal Axis



Unwedged Primary Axis



- Changes in beam quality produce differences in fluence through wedges
- Using data only from diagonal axes is not sufficient for accurate energy analysis, and change in fluence along the primary unwedged axes is used to determine fluence along diagonal, as if wedge were absent
- The width of the attenuated field, relative to the unattenuated field, has strong and monotonic relationship with beam quality (see Figures 1 & 2)
- The global quad wedge algorithm is applicable across most clinical energies for all linear accelerator types

Figure 1 (Photon)

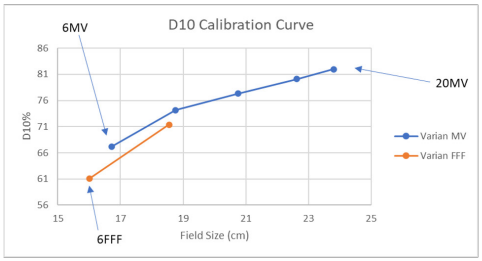
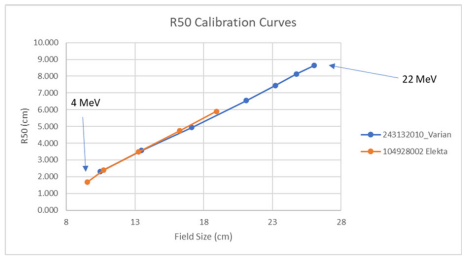


Figure 2 (Electron)



For photon curves, the FFF curve can adopt the shape of the flattening filter (MV) curve if there is only one FFF datapoint (as when a linear accelerator only has 6FFF). However, users are encouraged to enter a data point for each energy to ensure the most accurate results.

- The d10 accuracy for photons is accurate to within 0.3% beam quality change for photon beams with energies from 6-20 MV
- The d10 accuracy for flattening filter free photons is 0.7% for beams within 6FFF-10FFF
- The R50 accuracy for electrons is within 1mm for electron beams within 4MeV-22MeV
- Users can utilize either the 20cm^2 or 25cm^2 cone for this calibration

Faster, Easier, More Accurate

Energy verification using IC PROFILER with Quad Wedge accessories can yield results with accuracy comparable to water tank measurements. The setup of an IC Profiler and accessories is much simpler than the setup of a water scanning system. This means that the IC PROFILER is less prone to errors and uncertainties, which provides more consistent reproducible results.