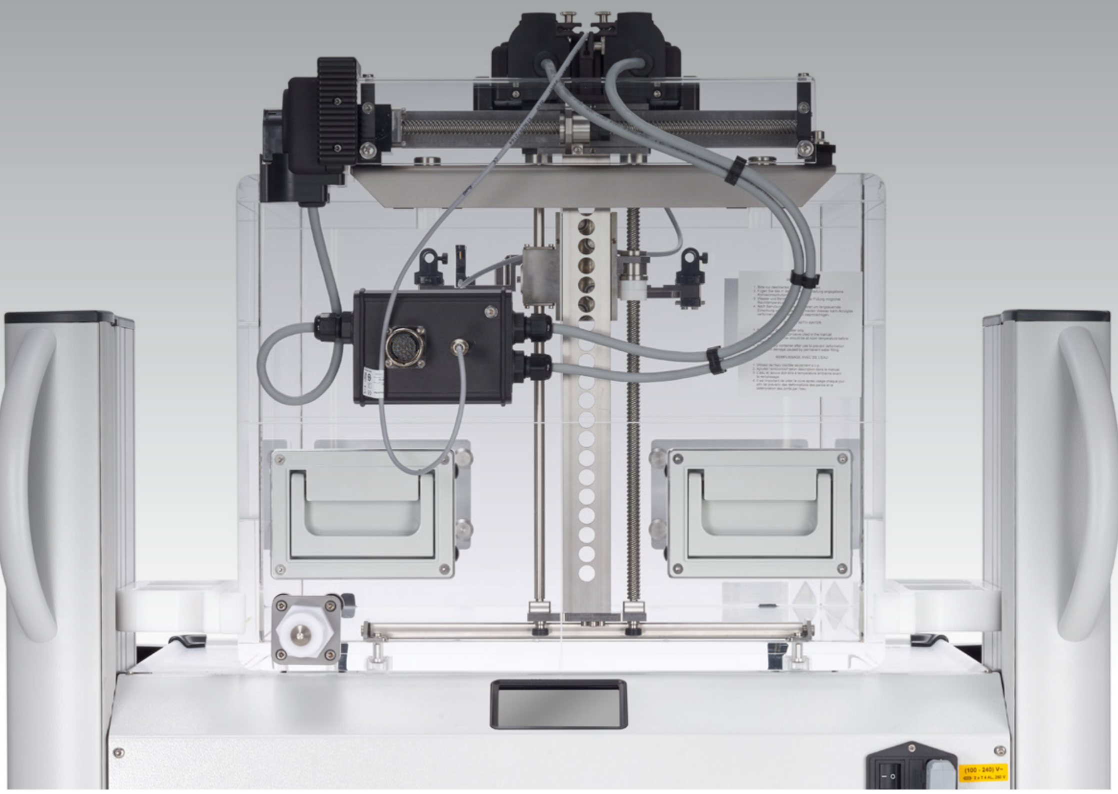
Case Study

January 2023

Use of the BEAMSCAN® MR Water Phantom for Commissioning and Quality Assurance of a ViewRay® MRIdian® Linear Accelerator: On-site trial and results

By Joshua Kim, Senior Associate Medical Physicist, Henry Ford Cancer Institute, USA

Trials of BEAMSCAN® MR Water Phantom at Henry Ford Cancer Institute Demonstrate Improved Commissioning Efficiency and Accuracy



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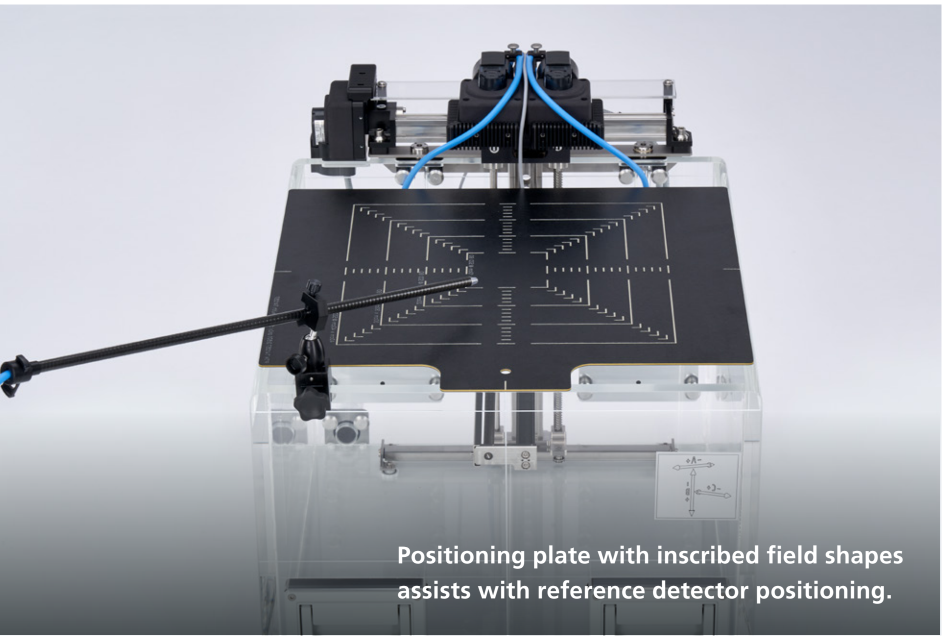


Positioning plate with inscribed field shapes assists with reference detector positioning.

The Henry Ford Cancer Institute acquired a ViewRay® MRIdian® linear accelerator (LINAC) to add to its arsenal of state-of-the-art radiotherapy treatments for patients. However, challenges in commissioning MR-guided LINACs can extend operator time from several hours to multiple days. Prior to installation of the MR LINAC, robust, MR-compatible 3D water scanning equipment was not commercially available. This left the medical physicists using other methods and dosimetry equipment for beam data acquisition that were far less efficient and much more time intensive.

To help alleviate these issues, Joshua Kim, Ph.D., senior associate medical physicist, and his team tested the BEAMSCAN® MR water phantom, designed especially for use with MR LINACs in strong magnetic fields. In fact, the team at the Henry Ford Cancer Institute were the first group in North America to thoroughly test the new 3D water scanning system and acquire beam data on a ViewRay MRIdian LINAC.

To increase operator efficiency, the BEAMSCAN MR water phantom enables an automated setup, which aligns the phantom coordinate system virtually to the LINAC coordinate system. The auto setup includes a patented auto-leveling function that aligns the scanning axes virtually to the water surface without moving the tank or scanning arms.
A positioning plate with inscribed field shapes assists with reference detector positioning outside the MR LINAC bore.

Setting up the BEAMSCAN® MR Water Phantom

Dr. Kim and his team found preparing the phantom for operation to be an easy process with a minimal learning curve.

The BEAMSCAN MR system comes on a compact, easy-to-move trolley with a touch panel to simplify system setup in the treatment room. The trolley integrates a large water reservoir for automatic tank filling and draining and high-precision electrometers for fast, accurate beam data acquisition.

The BEAMSCAN MR water phantom features a simple plug-and-go design with all of the electronics and cables built into the system, requiring only a few connections. Setup is as simple as putting the scanning tank on the treatment couch, lining it up with the LINAC, plugging in the power cord, mounting the detectors and filling the tank with water.

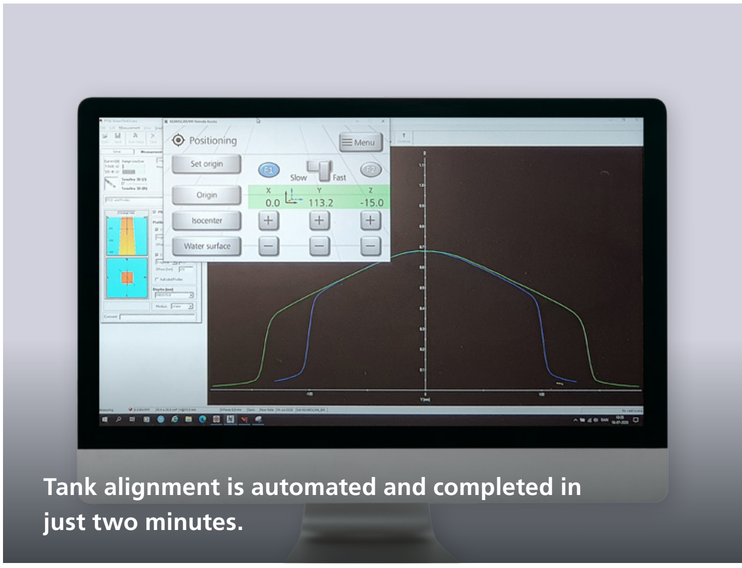
Installing the field detectors in axial or radial orientation is simple using the clip-in TRUFIX® detector holding system.

Filling and draining the water tank takes only four to five minutes and is fully automated. A water sensor controls the filling pump and checks the water level to prevent overflowing and spilling.

With the convenient Remote Access software, which is operated from the control room, the medical physics team at Henry Ford were able to perform the virtual alignment process in a simple guided workflow.

"A patented auto-leveling function aligns the scanning axes of the water phantom virtually to the water surface without physically moving the tank or scanning arms."

The tank fits perfectly into the ViewRay MRIdian bore.



Tank alignment is automated and completed in just two minutes.

Commissioning PDDs: BEAMSCAN® MR vs. 1D Tank

Taking measurements for commissioning percentage depth doses (PDDs) and profiles of an MR LINAC using a manual 1D scanning tank was a very time-consuming process for the medical physics team because they had to repeatedly enter the room to shift the ionization chamber and take multiple measurements at each data point. When using a 1D tank, acquiring the number of measurements needed to get a full set of PDDs took several days. This included taking 5 cm steps. Once the maximum dose was achieved, the steps were cut down to 0.5 mm, but even that took an extra two to three hours.

The BEAMSCAN MR water phantom proved to be much more efficient and accurate when measuring PDDs. Because of the increased efficiency, the physicists were able to acquire PDDs with much better resolution for a full set of field sizes, as compared to measuring only one PDD in the 1D tank.

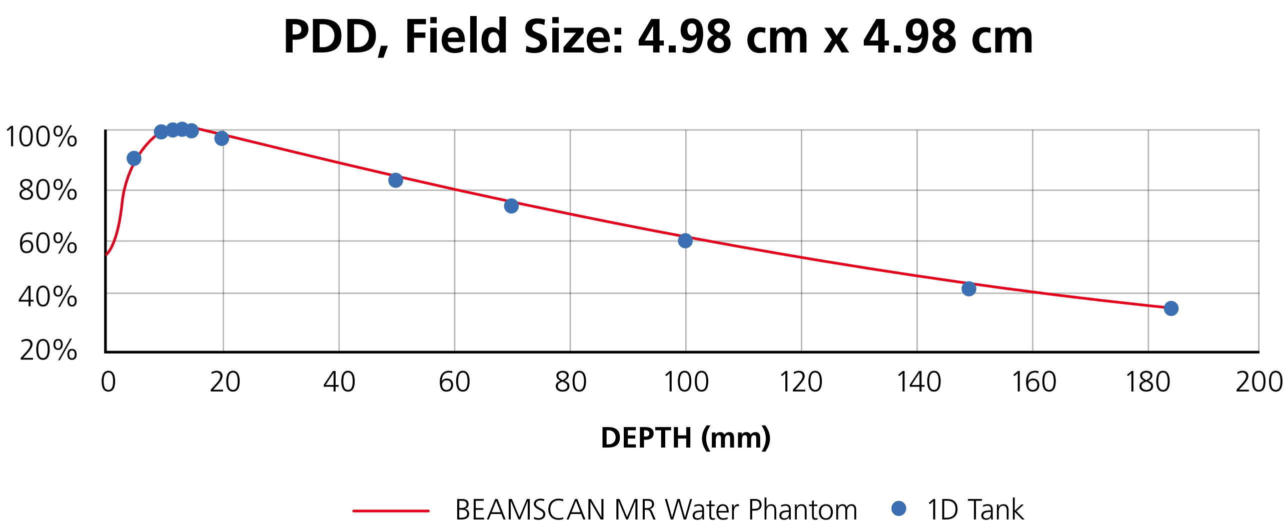
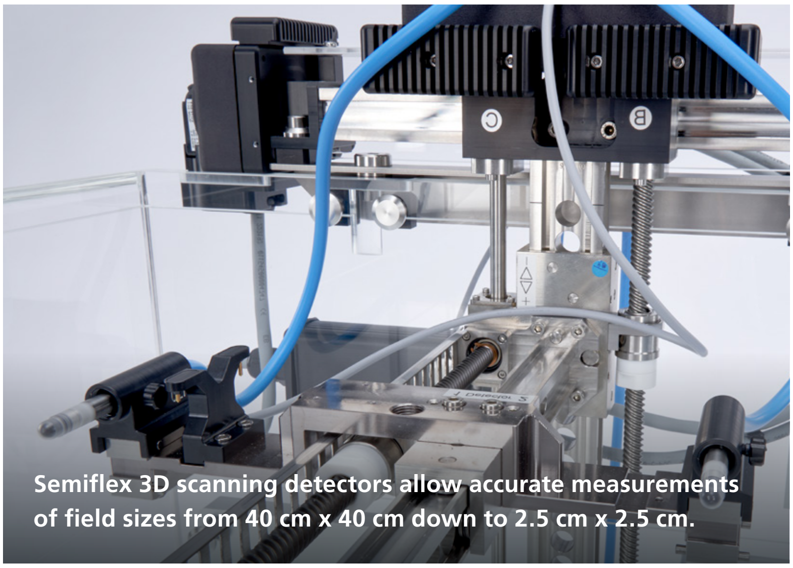


Figure 1: BEAMSCAN MR water phantom vs. 1D tank



Semiflex 3D scanning detectors allow accurate measurements of field sizes from 40 cm x 40 cm down to 2.5 cm x 2.5 cm.

Advantages of BEAMSCAN MR compared to a 1D tank:

- No couch shifts between measurements
- Fewer setup steps
- Setup consistent with planning conditions
- Better resolution, higher accuracy

In addition, BEAMSCAN MR water phantom measurements agreed closely with the values of the treatment planning system (TPS). The team obtained a D_{max} within 0.6 mm for all field sizes and PDD values within 1% for all depths down to 20 cm.

Thin-walled windows on both sides of the tank enable PDD and profile measurements at gantry angles of 90° and/or 270°.

PDD, Field Size: 4.98 cm x 4.98 cm

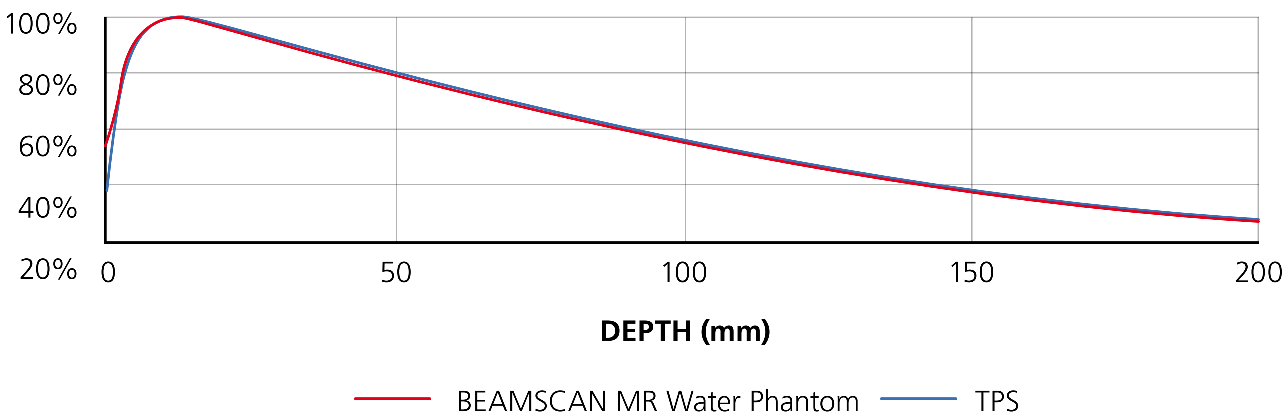


Figure 2: BEAMSCAN MR water phantom vs. TPS

Field Size (cm)	BEAMSCAN MR WATER PHANTOM				TPS				Difference			
	D_{max} (cm)	%dd(5)x	%dd(10)x	%dd(20)x	D_{max} (cm)	%dd(5)x	%dd(10)x	%dd(20)x	D_{max} (cm)	%dd(5)x	%dd(10)x	%dd(20)x
3.32 x 3.32	1.25	78.4	54.5	26.8	1.27	78.3	54.1	56.6	-0.02	0.0	0.3	0.2
4.98 x 4.98	1.30	80.5	56.4	28.4	1.34	80.1	56.1	27.9	-0.03	0.4	0.3	0.5
6.64 x 6.64	1.33	81.2	57.9	29.5	1.35	81.0	57.6	29.0	-0.02	0.2	0.3	0.6
9.96 x 9.96	1.33	82.3	59.9	31.3	1.30	82.0	59.4	30.7	0.03	0.3	0.5	0.6
14.94 x 14.94	1.27	83.3	51.9	33.2	1.33	83.0	61.2	32.5	-0.06	0.4	0.8	0.7
24.1 x 27.4	1.36	84.1	63.7	35.1	1.37	83.8	62.9	34.4	-0.01	0.3	0.8	0.8

Table: BEAMSCAN MR water phantom PDD measurements compared to TPS

Commissioning Large-Field Profiles: BEAMSCAN® MR vs. Detector Array

Original commissioning of the MR LINAC for large-field profiles required a 2D ionization chamber array with 5 mm spacing and fixed positions, making increased resolution in penumbras impossible. This led to boxy profile edges.

The BEAMSCAN MR water phantom allowed for adjustable scanning resolution between penumbra and flatter regions, making it possible for the team to acquire profiles quickly and efficiently.

The medical physics team then compared scans at multiple depths against TPS values. The Film Analysis software was used to import and convert the DICOM data from the ViewRay MRIdian LINAC TPS. The TPS data was then compared against measured data using the BEAMSCAN Data Analysis software. The analysis showed that field sizes, symmetry and flatness were all within 1% or 1 mm of profiles at all depths in the full set. Additionally, all field sizes and depths passed gamma criteria at 1% or 1 mm outside.

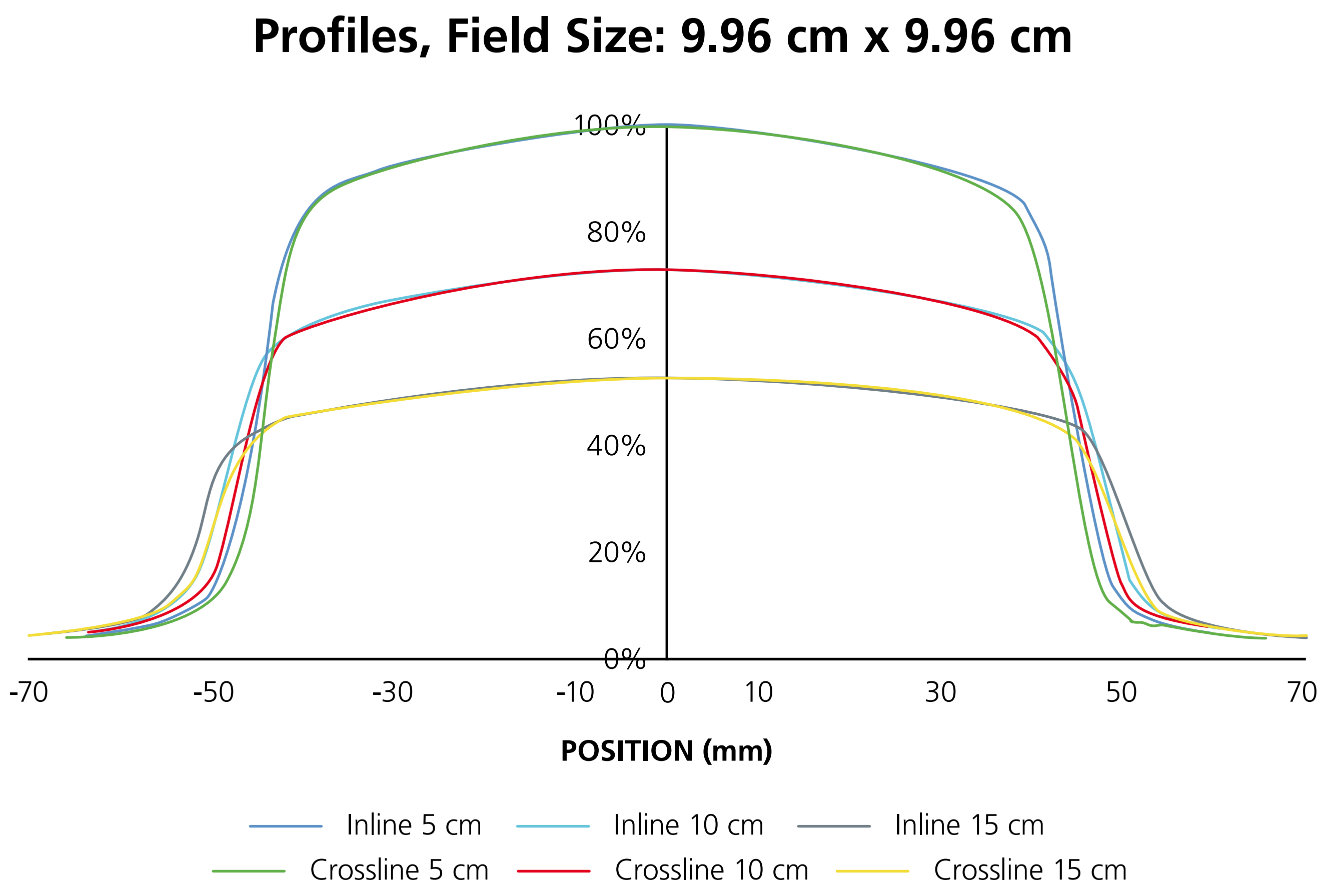


Figure 3: Full set of BEAMSCAN MR water phantom profiles

Crossline Profiles, Field Size: 9.96 cm x 9.96 cm, 5 cm Depth

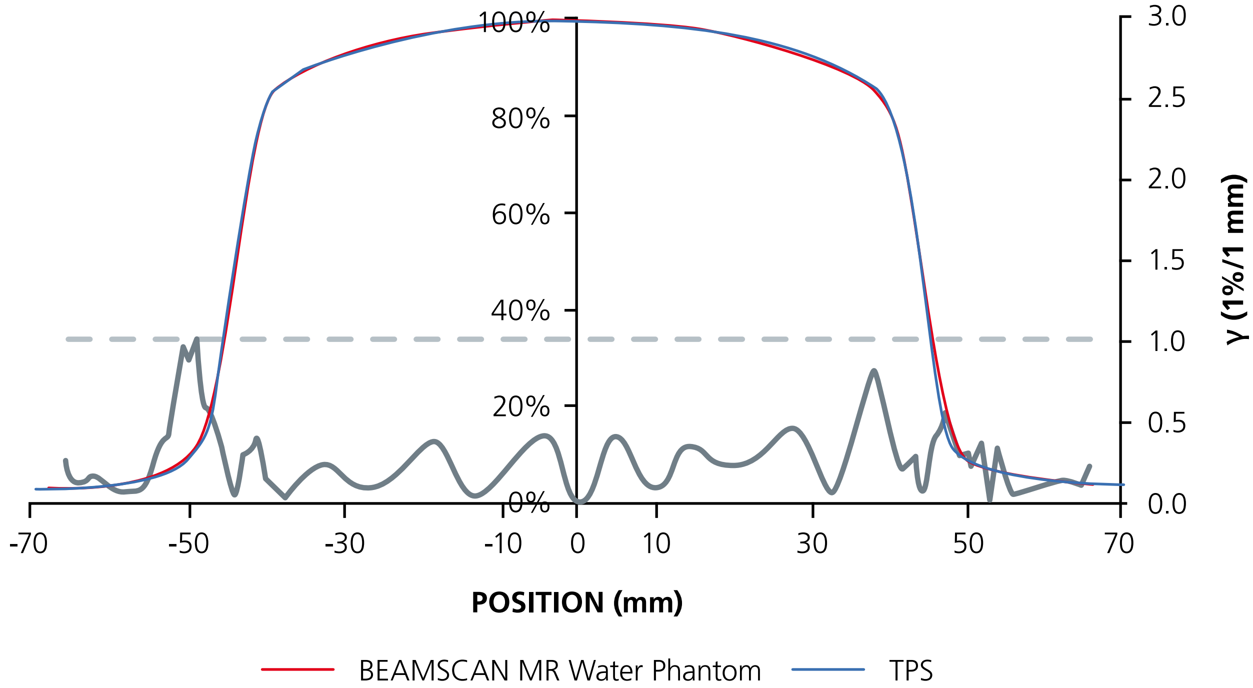


Figure 4: Crossline data comparison from large-field commissioning using BEAMSCAN MR water phantom vs. TPS

Inline Profiles, Field Size: 9.96 cm x 9.96 cm, 5 cm Depth

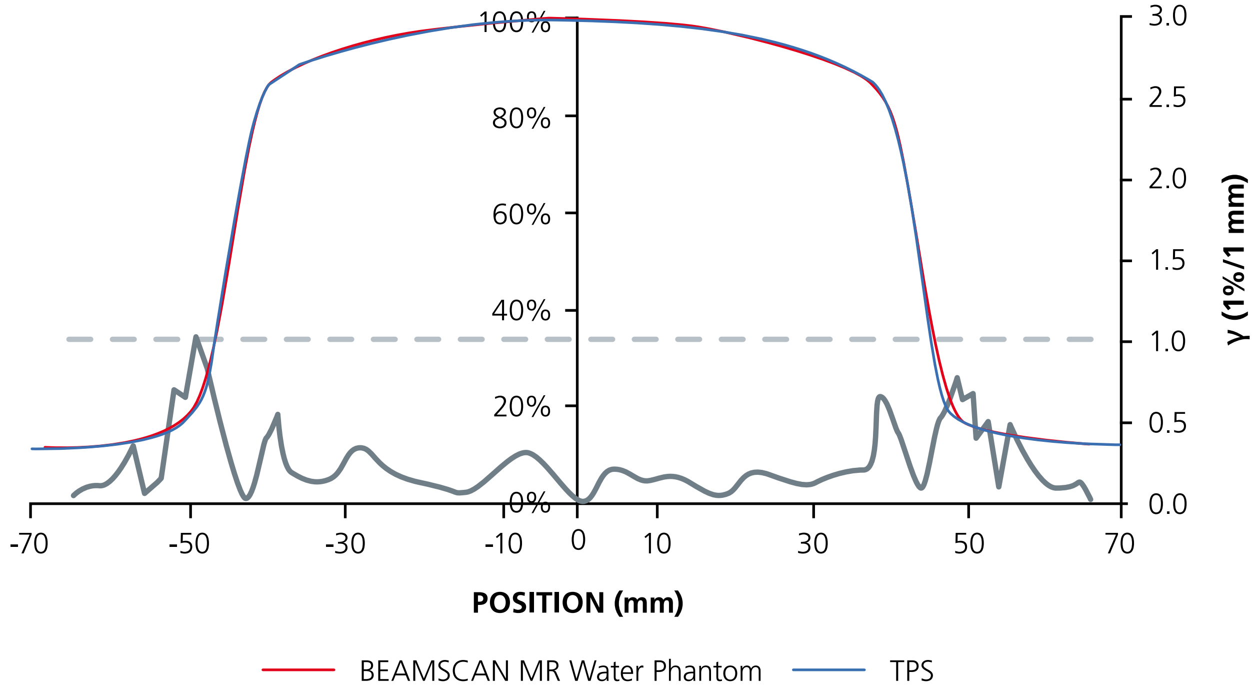


Figure 5: Inline data comparison from large-field commissioning using BEAMSCAN MR water phantom vs. TPS

Commissioning Small-Field Profiles: BEAMSCAN® MR vs. 1D Tank

The standard for commissioning small-field profiles is with a 1D tank because a detector array does not produce an adequate resolution. However, commissioning with the 1D tank is very time-consuming because the beam needs to be centered, and repeated measurements require small table shifts in-plane and cross-plane, keeping the maximum point along each direction at the beam center. Waiting for the water to settle after shifting the table added more time to the process, so that one small-field profile could take as long as four hours.

Testing the BEAMSCAN MR water phantom for small-field commissioning, Dr. Kim and his team used PTW's microDiamond® single crystal diamond detector with 1 µm thickness, which shows almost no deviations in absorbed dose to water even in the smallest field sizes. The microDiamond detector, used with the PTW TRUFIX® holder, did not require an effective point of measurement to be separately set.

They conducted a full range of profiles at 75 cm SSD at depths of 5, 10 and 15 cm in less than two hours. Field size differences were within 1 mm of TPS values for all field sizes, showing the high accuracy achieved with the BEAMSCAN MR water phantom.

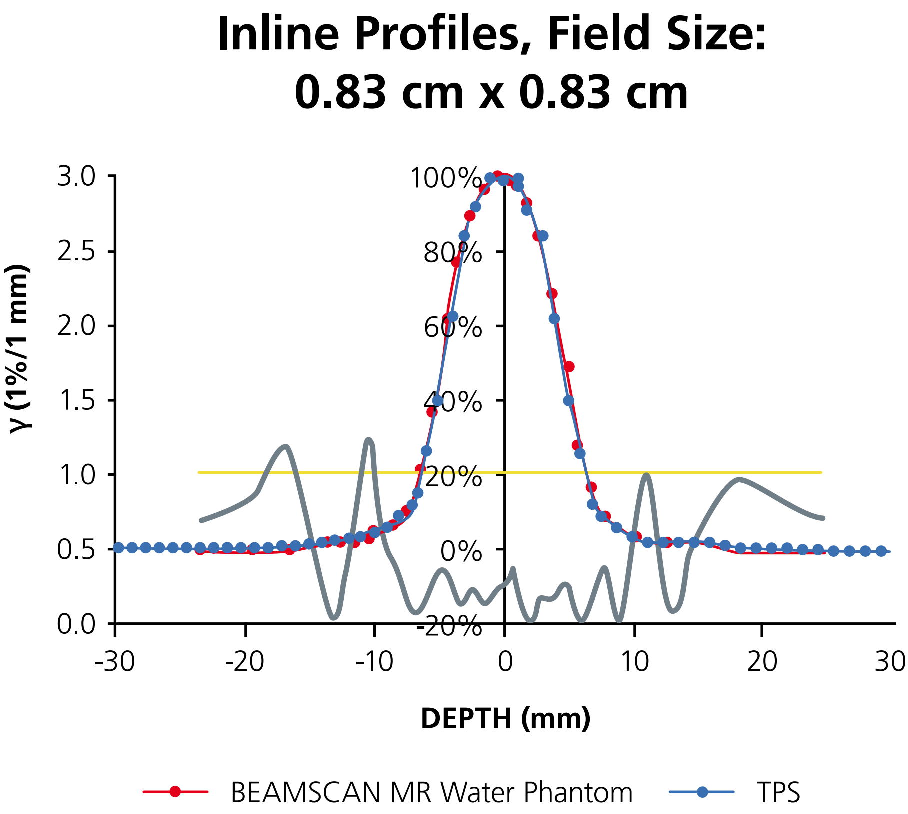


Figure 6: Data comparison of small-field commissioning using BEAMSCAN MR water phantom vs. TPS

Compatible with Other LINACs

Although the BEAMSCAN MR water phantom is optimized for easy use with the ViewRay MRIdian LINAC, it can be used on any conventional LINAC.
At Henry Ford, the physicists tested the BEAMSCAN MR water phantom on their newly commissioned Varian TrueBeam® LINAC and were impressed by the phantom's flexibility and ease of setup for PDD and profile measurements.
They tested 6FFF beam quality at field sizes of 3 cm x 3 cm and 10 cm x 10 cm with 100 cm SSD.

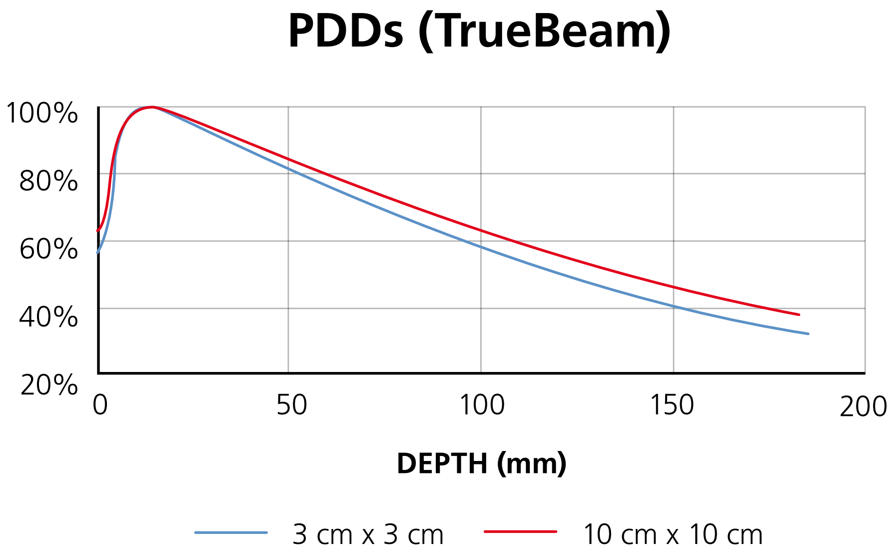


Figure 7: BEAMSCAN MR water phantom PDD measurements when used with TrueBeam LINAC

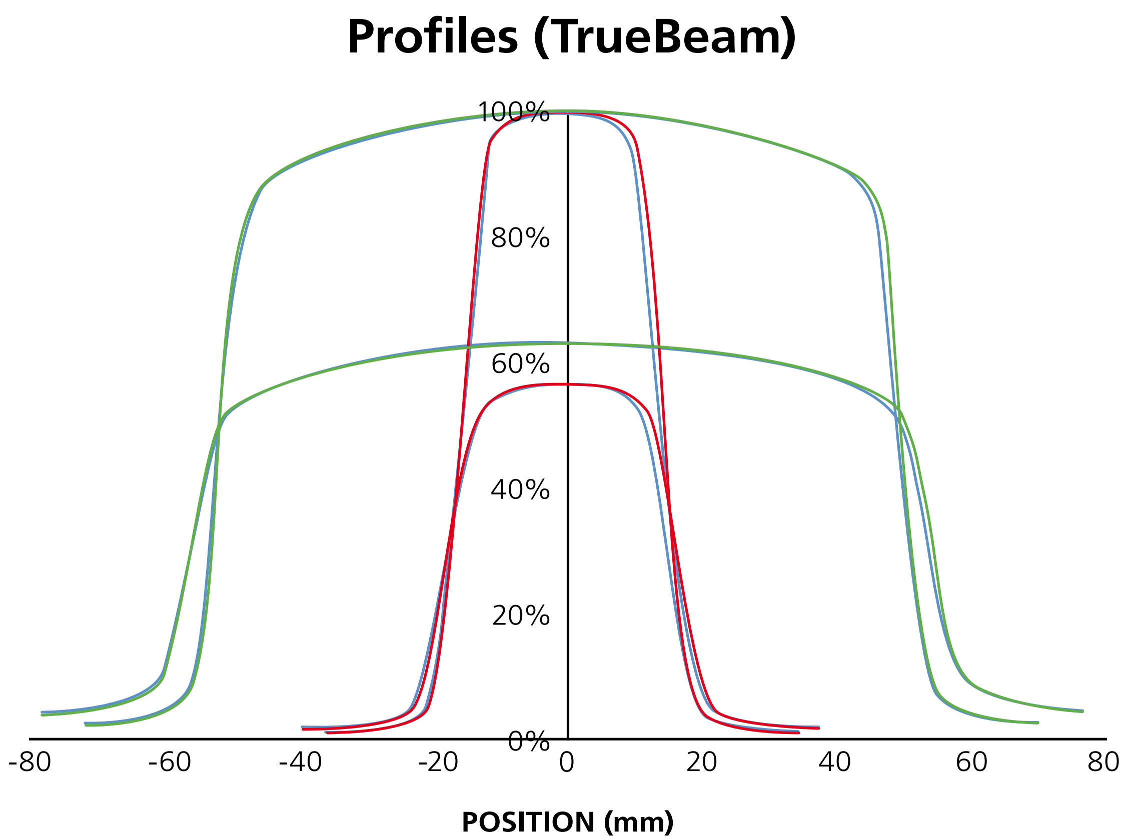
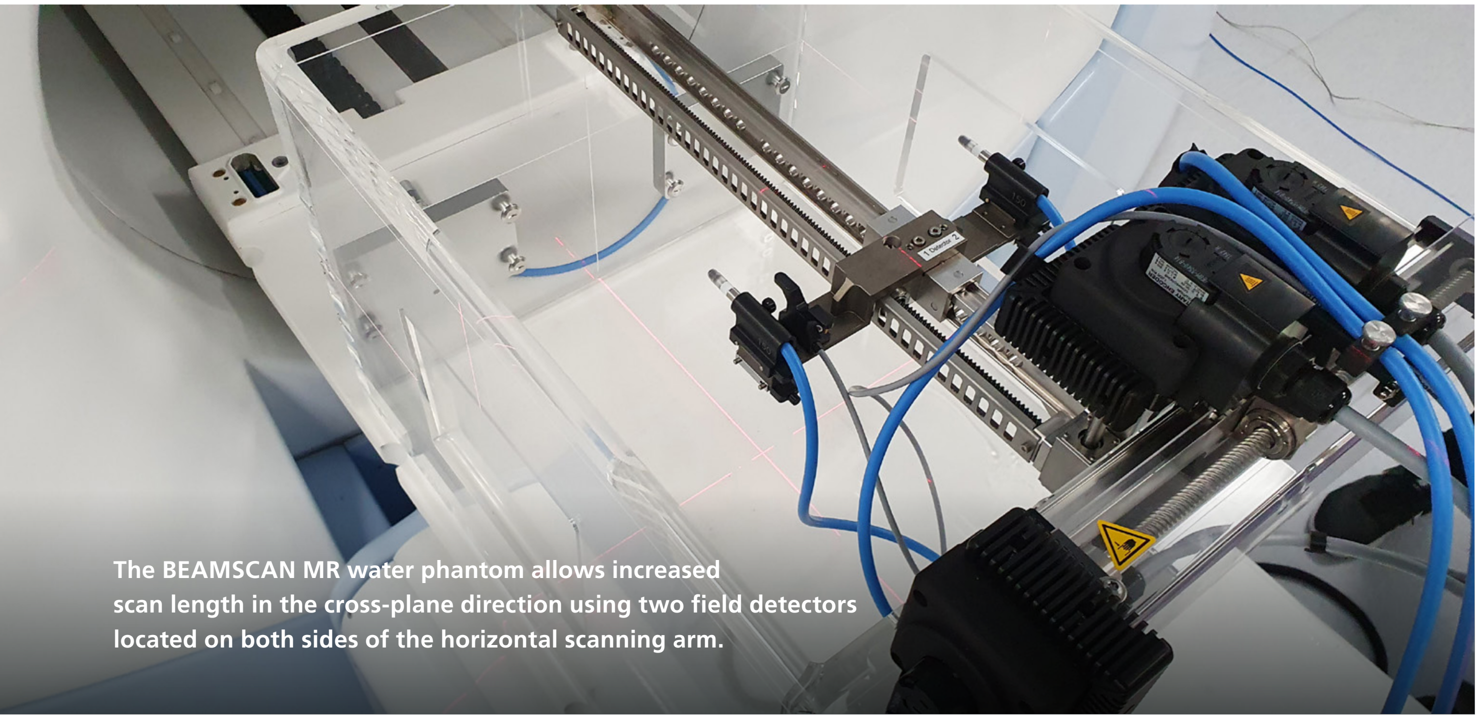


Figure 8: BEAMSCAN MR water phantom profile measurements when used with TrueBeam LINAC

Improved Speed and Pinpoint Accuracy

Dr. Kim and his team found that using the dedicated BEAMSCAN MR water phantom with their ViewRay MRIdian LINAC enabled faster setup and a wider range of measurements to obtain significantly more data values in a much shorter amount of time. They were also impressed by the data accuracy of the system that was always consistent with TPS values. They look forward to the finalization of the purchase process, so they can use the BEAMSCAN MR water phantom for commissioning and routine machine QA measurements of their MR LINAC at the Henry Ford Cancer Institute.



The BEAMSCAN MR water phantom allows increased scan length in the cross-plane direction using two field detectors located on both sides of the horizontal scanning arm.

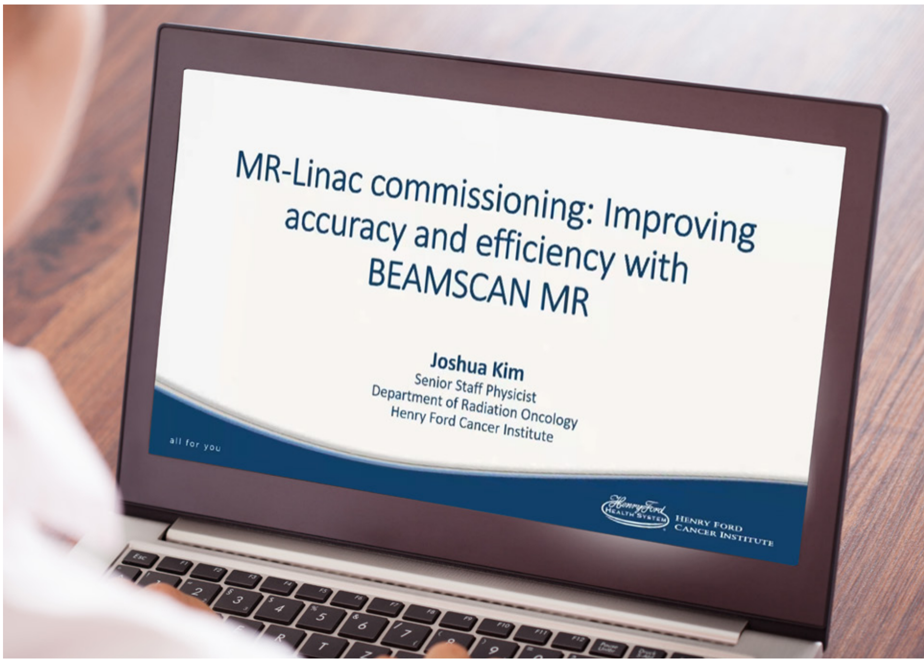
Personal

Joshua Kim
Holds a Ph.D. in biomedical sciences/medical physics from Oakland University. He is board-certified in therapeutic medical physics and currently serves as a medical physicist at Henry Ford Health System, Department of Radiation Oncology, Detroit (MI), USA, where he is also responsible for commissioning and quality assurance of the ViewRay MRIdian MR LINAC. His clinical work and research interests include new modalities for simulation imaging and image-guided radiotherapy, with a focus on online adaptive radiotherapy.

Watch the Webinar

More information can be found in the webinar "MR LINAC Commissioning: Improving Accuracy and Efficiency with BEAMSCAN MR Water Phantom."

Scan the QR code or check the webinar page of the PTW website.



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