Application of the MIMI Phantom as an Isocenter Verification Tool

Introduction:

The MIMI Phantom was designed for multiple purposes. Using this phantom, six AAPM Task Group (TG) 142[1] tests can be accomplished. In 2011, an aluminum oxide bb with a diameter of 6.4 mm was added to the center of the phantom. The dimensions of the phantom are 14x14x14 cm^3, and there are a total of 5 bone equivalent rods drilled into the phantom (4 of which intersect at 90 degrees). The phantom itself is composed of an acetal copolymer, much like the Winston-Lutz Cube Phantom.

There are some limitations to consider in using the MIMI for Winston-Lutz. The density of the aluminum oxide ball is approximately 3.95 g/cm^3, which is much less than the phantoms using Tungsten (19.5 g/cm^3). This density is only slightly higher than the acetal cube (1.41 g/cm^3). Additionally, the bone equivalent rods have a density of 1.85 g/cm3, and the proximity to the centrally located aluminum oxide ball could cause an issue with the angles of a Winston-Lutz.

Several fiducials are painted black on the phantom, and the letters H (head), F (foot), L (Left), and R (right) provide easy alignment capabilities, as shown in Figure 4. The alignment of the phantom simulates the alignment of a patient head first in a supine position on the couch.

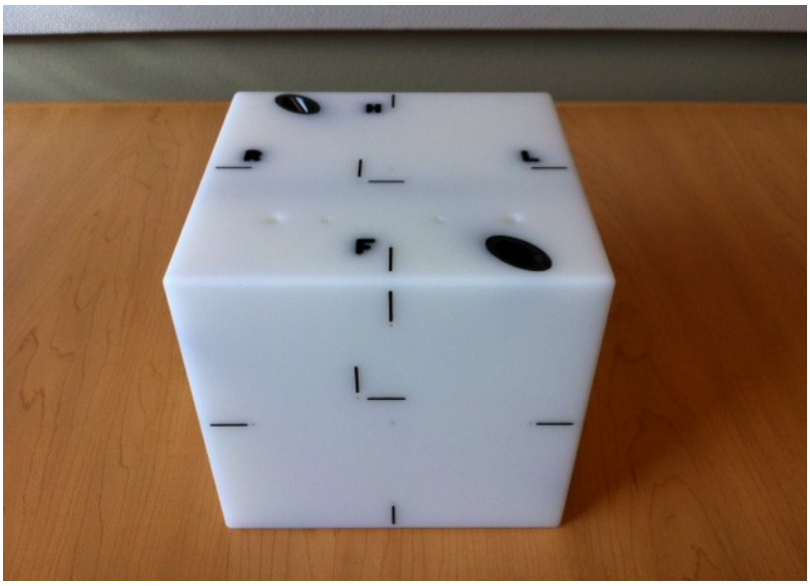

Figure 1. The MIMI Phantom showing the easy to comprehend supine alignment of positioning.

Methods

The phantom is marked mimicking a patient who is lying head first on the couch in the supine position. The testing was accomplished on a Varian (Varian Medical Systems, Palo Alto, CA) Truebeam linear accelerator, with the Varian Electronic Portal Imaging Device (EPID) positined at 50 cm. The side lasers were aligned to the horizontal fiducial to ensure that the center of the 5 mm tungsten ball was at 100 cm. The light field cross hairs were aligned to the orthogonal fiducials on top of the phantom, ensuring that head (H) was proximal to the target, and foot (F) was distal.

The image was taken with 6 MV, approximately 3 MU, with a dose rate of 400 MU/min. The

resolution was set at 1024x1024. To follow the same procedure recommended for the Stereotactic module of PIPSpro, the field size was attempted to be set at 1.2 x 1.2 cm^2. Table 2 shows the angles attempted in this study.

Due to 3D graphical analysis provided by Chris Bonde, it appears that the only logical angles for this phantom using the recommended alignment, are as follows:

Table 1. Angles that provide a clear view of the bb, without inclusion of bone rods

Gantry	Couch
270	90
90	270

Unfortunately, these angles cannot be used. In order to meet these angles, the imaging panel would have to go through the couch.

Our intent was to shoot this phantom with several different angle combinations in an attempt to find eight pairings that could provide enough of a spread for a confident Winston-Lust test in PIPSpro. Based on Chris Bonde's rendering, the below table shows the angle that were worth looking at.

Table 2. Possible angles that provide a clear view of the bb

Gantry	Couch
0	0
0	90
0	45
0	315
0	270
90	0
180	0
270	0
315	90

Results

Using a third party dicom reader created by the product manager, we were able to analyze the images taken with the MIMI phantom. The following figure show an example of the images acquired using the MIMI phantom.

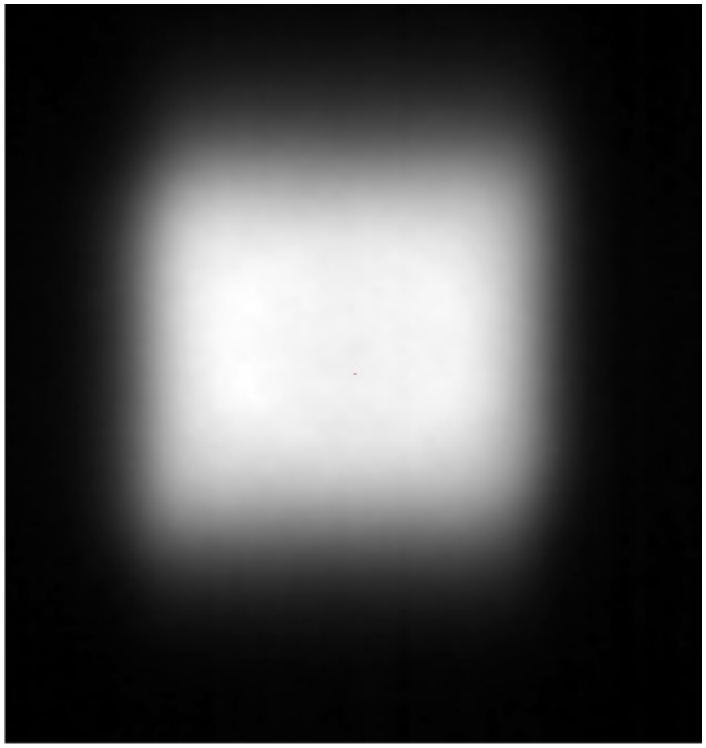

Figure 2. Image taken at G270C0

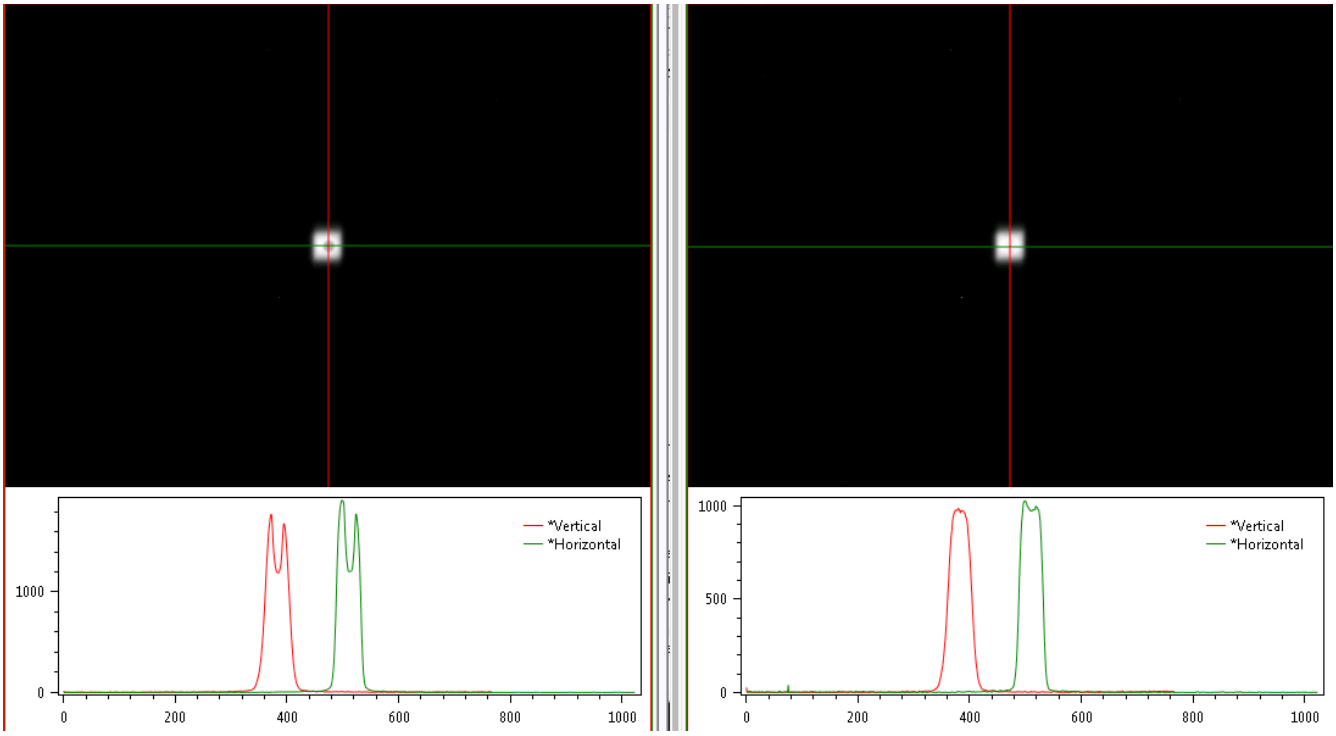

Figure 3. Comparison of the peaks associated with the central bb determination between the Varian E2E phantom and the MIMI phantom.

Discussion:

Though there was promise with the MIMI phantom, the lower density bb, closely positioned to the bone rods of similar density, was too much to overcome for Winston-Lutz verification. Figure 2 shows that the contrast similarities between the ball, the material, and the bone rods are close enough to make the bb undeterminable by our software, or the third party dicom viewer that was used for analysis.

A comparison between the Varian E2E phantom and the MIMI phantom at the center of the bb are shown in Figure 3. The third party software shows the left image, Varian E2E phantom, peaks where the contrast is much lower in the irradiated field, and the peaks drop to show the higher contrast of the bb. The presence of this drop in the peak, due to the contrast of the bb, is not present in the MIMI phantom analysis. This shows that the bb is not recognized.

The other issue with the MIMI, as stated before, is there are only two clear angles that would display the center bb without any interference from the contrast of the bone rods. As was discussed, these two angles are only accomplishable by crashing the imager or gantry through the couch, which is not recommended. The other possibility would be to rotate phantom on the couch to make the angles accomplishable. This would cause the ease of alignment to suffer, which would lose the major advantage of the MIMI. Additionally, this would still only provide two good images, and that is not enough to even cover the lax standards of our competition (some only recquire four images). Thus, while it would have been great, we have deemed the MIMI unusable for WL testing.

References

1. AAPM TG 142