Magphan Phantoms for MR for radiation therapy and quantitative imaging applications.

Smári

Sub-voxel geometric distortion measurements and critical image quality metrics engineered for ease of use in the clinical workflow.

The Phantom Laboratory manufactures high-precision phantoms coupled with Smári image analysis service and innovative custom solutions for the medical imaging and radiation therapy fields.

Click to see our latest phantoms and schedule a demo of our Smári image analysis service.

phantomlab

phantomlab.com

Erratum: "Gamma electron vertex imaging and application to beam range verification in proton therapy" [Med. Phys. 39(2), 1001–1005 (2012)]

Chan Hyeong Kim[a)] and Jin Hyung Park
Department of Nuclear Engineering, Hanyang University, 17 Haengdang-dong, Seongdong-gu, Seoul 133-791, Republic of Korea

Hee Seo
Nonproliferation System Research Division Korea Atomic Energy Research Institute (KAERI), 989-111 Daedeok-daero, Yuseong-gu, Daejeon 305-353, Republic of Korea

Han Rim Lee
Department of Nuclear Engineering, Hanyang University, 17 Haengdang-dong, Seongdong-gu, Seoul 133-791, Republic of Korea

(Received 14 August 2012; accepted for publication 15 August 2012; published 3 October 2012)

[http://dx.doi.org10.1118/1.4749930]

In a recent Letter,[1] our group introduced the new idea of "gamma electron vertex imaging (GEVI)" for beam range verification in proton therapy. In the Letter, we mentioned that the proton beam range can be determined within 2–3 mm error by using GEVI. Recently, however, we found that multiple Coulomb scattering (MCS) process for electron was mistakenly omitted in our Geant4 simulation. It was a serious mistake. Therefore, we have repeated the simulation study again including the MCS process, and this letter provides the revised result.

The new simulation conditions were identical to those of the previous simulation with two exceptions: (1) The MCS process was included in simulation. (2) The convertor was changed to 1.08-mm-thick beryllium to minimize the effect of MCS. As was in the previous simulation, 1.2 $\times$ 10^9 protons were incident on the phantom at two locations: 5 and 15 cm from the surface of the phantom on the GEVI side. For image reconstruction, we employed a Markov-chain based stochastic origin ensemble (SOE) algorithm.[2,3]

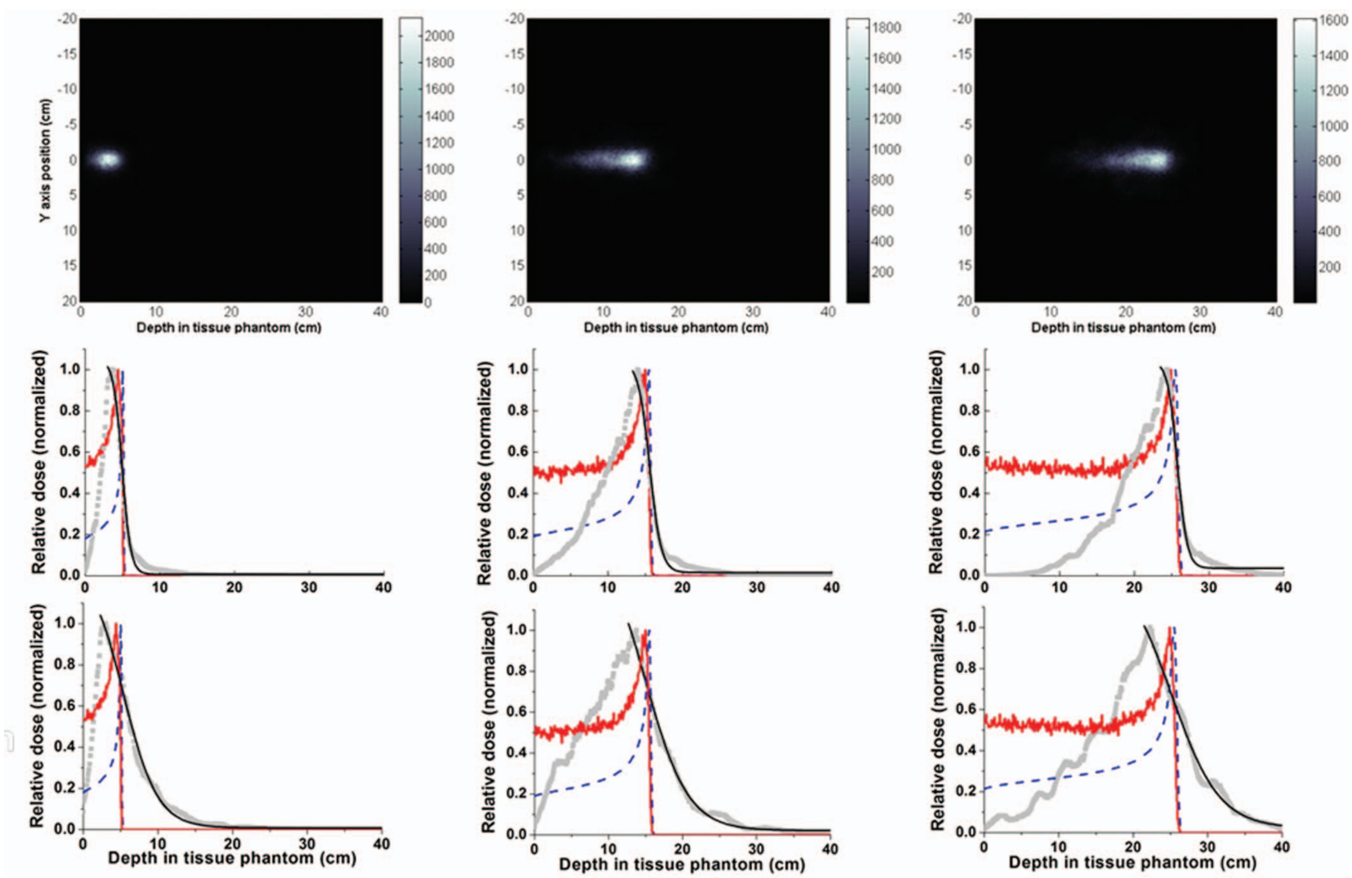

FIG. 1. GEVI image and projections. The upper plots show the results for $d = 5$ cm. The lower plots provide the GEVI image projections (gray square markers) and prompt gamma distributions (red step lines), along with the distributions of absorbed dose (blue dash lines).

Figure 1 shows new simulation results. The upper images show the reconstructed GEVI images for $d = 5$ cm. The lower plots provide the GEVI image projections (gray square markers) and prompt gamma distributions (red step lines), along with the distributions of absorbed dose (blue dot lines). For the purposes of a quantitative analysis, the projection data were fit to the sigmoidal Boltzmann equation (black lines).

Compared with the previous results, the new results show more blurry image due to MCS interactions of electrons in the convertor. The results, however, still indicate that the projections of GEVI images are strongly correlated with the distributions of absorbed dose (which was the main conclusion of our letter); the projections sharply dropped near the Bragg peak. With sigmoidal Boltzmann curve-fitting, it was found that the phantom depth corresponding to the half maximum of the projection after the peak was always very close to the proton beam range (= the depth corresponding to the 80% dose level in the distal dose falloff). The results established that the proton beam range can be determined within 3–6 mm of error.

In conclusion, we still believe that the GEVI has a great potential for proton beam range verification. For precise measurement, however, it is necessary to minimize the MCS effect. In this letter, we showed that the effect of MCS can be minimized by two approaches: (1) by using an optimal convertor which has a low density and thin thickness, and (2) by using an advanced image reconstruction algorithm such as SOE or expectation maximization. In the near future, we will submit a full paper on GEVI, which will discuss these issues in a great detail and, we hope, minimize the impact of our mistake.

[a]Author to whom correspondence should be addressed. Electronic mail: chkim@hanyang.ac.kr

[1]C. H. Kim, J. H. Park, H. Seo, and H. R. Lee, "Gamma electron vertex imaging and application to beam range verification in proton therapy," Med. Phys. **39**(2), 1001–1005 (2012).

[2]A. Sitek, "Representation of photon limited data in emission tomography using origin ensembles," Phys. Med. Biol. **53**(12), 3201–3216 (2008).

[3]A. Andreyev, A. Sitek, and A. Celler, "Fast image reconstruction for Compton camera using stochastic origin ensemble approach," Med. Phys. **38**(1), 429–438 (2011).