Quality Assurance of Radiotherapy using Scattered X-ray

SYSTEM REQUIREMENTS AND FUNCTIONAL SPECIFICATIONS

The system objective is to infer on the delivered radiation dose deposition inside a phantom using information on the photons scattered outside of the phantom. The system is depicted in Figure 1 and its units are described in the System Design document (see the project Wiki-page for details).

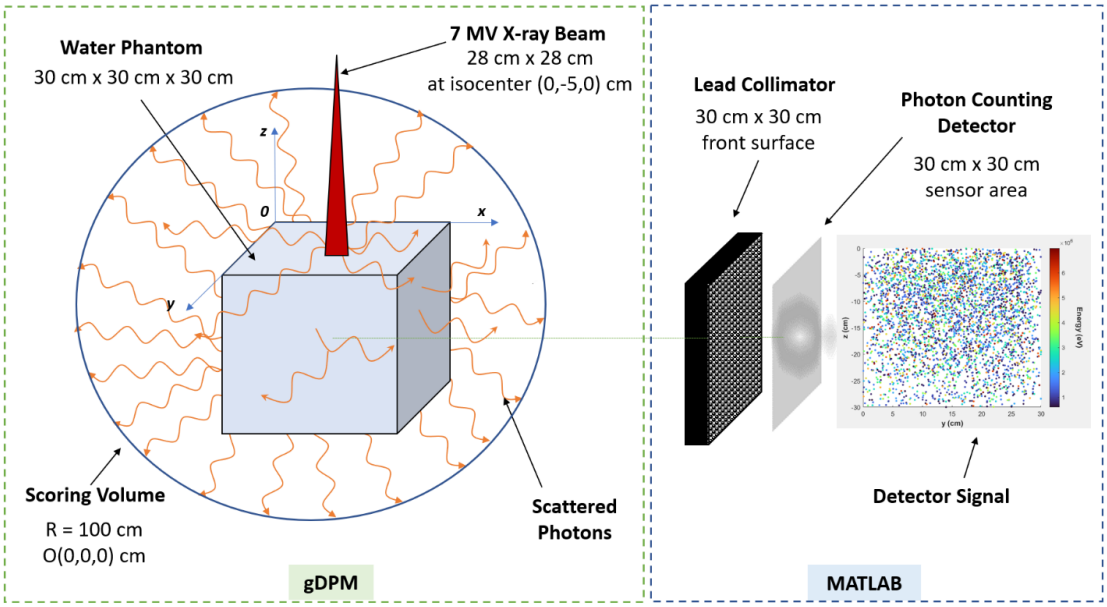

Figure 1. System design

The system comprises two parts: 1) The simulation of a MV x-ray beam transport through a phantom and the registration of the photons in a scoring volume; 2) The scattered photons' transfer from the scoring volume to a photon counting detector and the relation of the detector signal to the delivered radiation dose. The first part should be done using the gDPM Monte Carlo simulation package[1,2], while the second part must be implemented in MATLAB.

The inputs to Part I (gDPM):

- Scoring sphere center coordinates and its radius in cm
- Phantom material (matimage.img, matimage.header, density.img, density.header)
- Phantom dimensions in cm
- Beam cross-section dimensions at isocenter in cm
- The number of simulated photons (histories) in the beam

The outputs of Part I (gDPM):

- "dose.img" – a file with the dose in Gy/particle deposited in each phantom voxel
- "dose.header"– a file with a coefficient to convert the phantom voxels to cm

In the case of original (full-size) output files:

- "PSFpos.dat" – a file with photon positions in the scoring volume (x, y, z, r) in cm
- "PSFdir.dat" – a file with photon direction (x, y, z) in cm and photon energy in eV

In the case of reduced in size output files:

- "dirvec.txt" – a file with photon positions in the scoring volume (x, y, z, r) in cm
- "posvec.txt" – a file with photon direction (x, y, z) in cm and photon energy in eV

Here, PSF stands for a “phase space file” which is another name for the scoring sphere.

The inputs to Part II (MATLAB):

- The outputs of Part I (gDPM)

The outputs of Part II (MATLAB):

- A plot with 2D simulated depth-dose profile (.png)
- For the specified photon energy and distance between the phantom and detector:
    - A plot with 2D detector sensor signal (.png)
    - A heatmap of detected photon counts (.png)
    - A plot with longitudinal dose and photon counts profiles (.png)
    - A plot with dose values vs photon counts and coefficient of determination (.png)

The system must achieve R-squared ≥ 0.9 between the simulated dose and photon counts profiles.

References

1. Jia, X. & Jiang, S.B. (2011). gDPM v2.0. A GPU-based Monte Carlo simulation package for radiotherapy dose calculation. The Center for Advanced Radiotherapy Technologies (CART), UCSD.
2. Jia, X., Ziegenhein, P., & Jiang, S. B. (2014). GPU-based high-performance computing for radiation therapy. Physics in Medicine and Biology, 59(4), p. R151–R182.