FOX CHASE CANCER CENTER
TEMPLE HEALTH

Investigation of the Temporal and Spatial Output Fluctuation in the 45MV Photon Beam of the LA45 Racetrack Microtron

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JULY 12–16 2020 VIRTUAL
JOINT AAPM | COMP MEETING
EASTERN TIME [GMT-4]

INTRODUCTION

The LA45 racetrack microtron (Top Grade Healthcare) uses a cyclotron-like design for accelerating electrons and transports the accelerated electrons using focusing and bending magnets to the treatment head of a C-arm gantry. The accelerator is comprised of a S-band 5MeV linear accelerator and a pair of main magnets that reside on both ends of the Linac to steer the electrons through a race track back into the Linac for successive acceleration before beam extraction. It can produce an electron beam at 9 energy levels from 5MeV to 45MeV in steps of 5MeV. The extracted electron beam is transported to the treatment head where four scanning magnets are used to scan the electron beam before it striking a thin foil (for electron beam) or a target (for photon beam) to generate a broad, flat beam without the use of scattering foil or flattening filter. A scan pattern is formed by a number of electron beamlets with varying angles incident upon the target plane. For electron beams, the projection of the scan pattern forms a hexagon and for photon beams it forms a circle. For the 45MV photon beam, the nominal scan period is 0.2 second. The ultra-high energy 45MV photon beam is in favor of clinical applications for radio-dynamic therapy with much increased photosensitizer activation rate, and isotope (O-15, C-11, etc.) activation for potentially direct dose validation following radiation delivery.

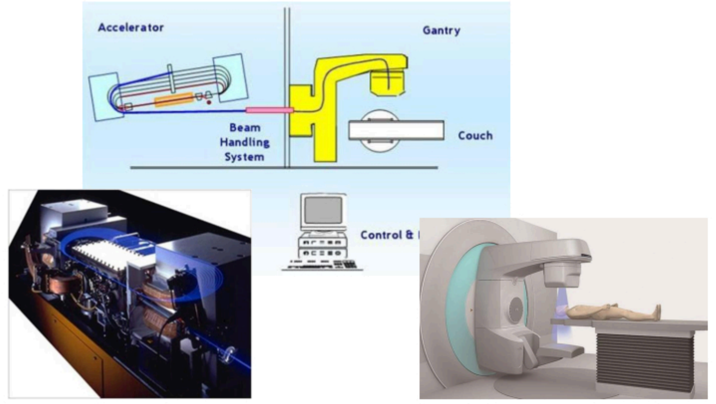


Figure 1. The configuration of the LA45 racetrack microtron. The racetrack accelerator and gantry are separated by a shielding wall. The accelerated electron beam is transported using focusing and bending magnets and is scanned by scanning magnets before striking the target to generate x-ray.

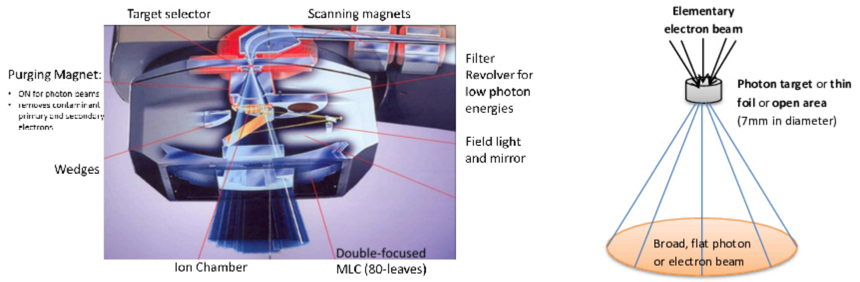


Figure 2. The major components of the treatment head. Two pairs of scanning magnets control the incidence angle of the electron beamlets before refocused at the same spot on the target plane. The target selector has 3 tungsten targets for low, intermediate and high photon energy, respectively, and 1 open hole, 2 thin foils for low, intermediate and high electron energy, respectively. The purging magnet is powered on only for photon beam to remove the contaminated electrons from the photon beam. An optional flattening filter is available for low photon energies.

AIM

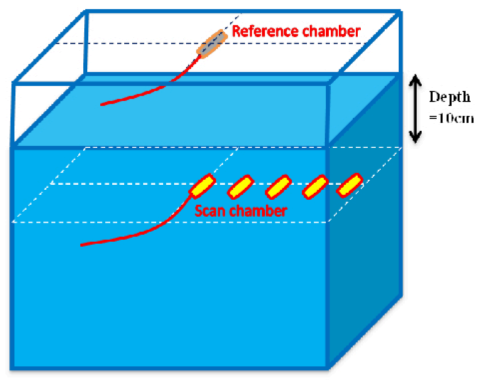
To investigate the in-field dosimetric fluctuation of the 45MV photon beam generated by the LA45 scanning beam accelerator.

METHOD

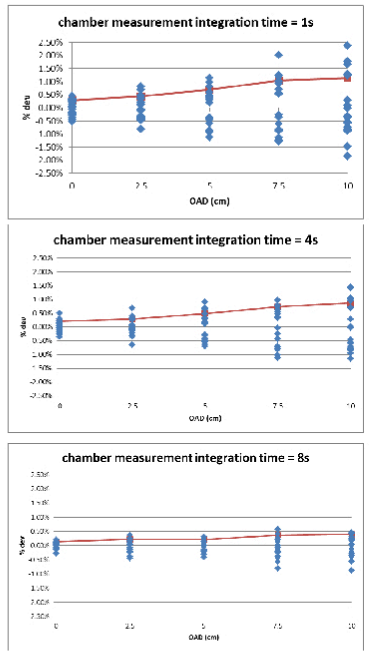
- Two 0.125cc ion chambers were used to simultaneously measure the in-air and in-water (10cm depth) ionization along central axis in the 45MV photon beam (SSD=100cm, field size 20x20cm^2, dose rate 300MU/min and scanning period 0.2s/cycle).
- The chamber readings were taken with three different integration periods (1s, 4s and 8s) and were each repeated by 20 times during continuous beam delivery.
- The above measurements were repeated with the chamber in water shifted to different off-axis distances at 2.5cm, 5cm, 7.5cm and 10cm, respectively.
- In addition, a 2D array detector (MatriXX) was used to measure the spatial dose fluctuation across the entire field and the measurement was repeated with different sampling rates (1s, 4s and 8s per snap).

RESULTS

(a)



(b)

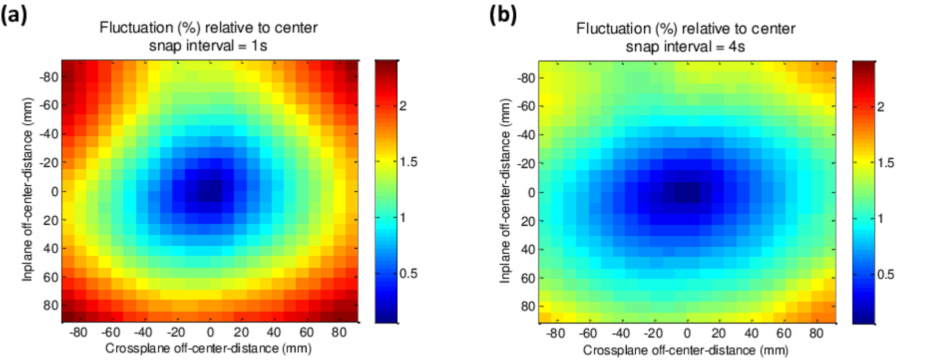


(c)

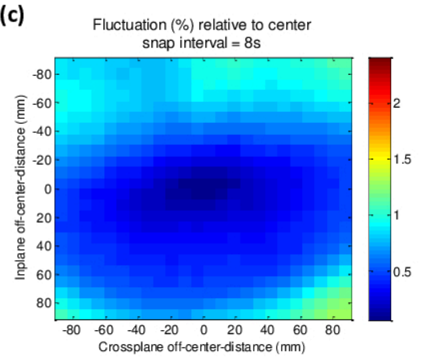
Off-axis distance (cm)	0	2.5	5	7.5	10
Std. dev. (int. time =1s)	0.29%	0.44%	0.69%	1.04%	1.13%
Std. dev. (int. time =4s)	0.21%	0.29%	0.49%	0.73%	0.87%
Std. dev. (int. time =8s)	0.14%	0.22%	0.21%	0.37%	0.40%

Figure 3. **(a)** Illustration of the chamber setup for measuring the output fluctuation of the 45MV scanning beam. The in-air chamber was placed on field central axis with 75cm from source and 25cm from water surface. The in-water chamber was placed at depth 10cm and moved to five different off-axis distances (OAD=0, 2.5, 5, 7.5 and 10cm). **(b)** The chamber readings were measured during continuous beam delivery with three different measurement integration time (1s, 4s and 8s). At each OAD of the in-water chamber, the readings were repeated 20 times. The ratio of the in-water to in-air chamber reading was calculated. The percent deviation (blue dot as plotted) was calculated as the percent difference between each reading ratio and the average in each setting of measurements. The red lines represent the standard deviations. **(c)** Summary of the output fluctuation measured at different OAD and with different chamber integration time.

(a) (b)



(c)



(d)

Snap interval	1s	4s	8s
(Min, Max)	(0.1%, 2.4%)	(0.1%, 1.8%)	(0.1%, 1.3%)
Mean	1.4%	1.0%	0.6%

Figure 4. **(a)-(c)** the 2D spatial output fluctuation map measured by Matrixx, with different snap interval.The detector plane of the Matrixx was set at SAD=100cm with field size 20x20 cm^2 and dose rate 300MU/min. The snap interval (sampling time) was set as 1s, 4s and 8s, respectively, for each measurement, with the corresponding number of snaps being 120, 40 and 30, respectively. For each snap, the dose map was first normalized to the center chamber reading. The spatial output fluctuation was measured by the standard deviation at each pixel over all snaps with the same snap interval. **(d)** Summary of the range of the spatial fluctuation and the mean value for different measurement sampling time.

CONCLUSIONS

When measuring the depth dose and beam profiles for the LA45 mircotron using a scanning chamber in water, a long chamber measurement period (>= 4s) is necessary to reduce the temporal and spatial output fluctuation. An alternative method using a 2D array detector (such as Matrixx or films) with sufficient MU is preferred. The characteristics of the output fluctuation of the scanning beam accelerator should be taken into account in treatment planning as a component of dosimetric uncertainty.

CONTACT INFORMATION

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