Investigation of Different Commercial Bragg Peak Chamber Using Monte Carlo Simulation

J. H. Phua[1], H. Q. Tan[1], K. W. Ang[1], A. Wibawa[1], Z. Master[1] and S. Y. Park[1]
1National Cancer Center of Singapore, Division of Radiation Oncology, Singapore

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

INTRODUCTION

Bragg peak chambers (BPC) are used in collecting integrated dose at various depth in water for proton therapy system. This data is important for commissioning Treatment Planning System and give information on the range of each energy layer. The challenge is however, the finite size of the diameter of BPC might lead to incomplete collection of the entire radial doses of the proton beam. In this work, we defined a correction factor term to represent the degree of incomplete dose collection at various depth of the depth-dose curve.

AIM

In this work, we investigate the magnitude of the correction factors for different commercially available BPC at different depth of the depth-dose curve. This is to find out the appropriate chamber to be used for the collection of the IDD of the proton beam and also to determine the depth of greatest correction factor along the depth-dose curve.

METHOD

3 commercially available Bragg Peak chambers simulated in TOPAS:

- PTW TN34070, 81.6 mm diameter
- PTW TN34089 , 147 mm diameter
- IBA Stingray, 120 mm diameter

Different beam energies 100 MeV, 150.3 MeV and 221.3 MeV are simulated with and without range-shifter.

Doses are collected in intervals of 2 cm in the water phantom.

Total dose collection was integrated at a certain depth known as the dose collected by the chamber at the depth, $D_{chamber}$.

The same was done for the 15cm radial score, which is the total dose collected known as the full dose collection, D_{full}.

The correction factor for each depth simulated is defined as ratio of D_{full} and $D_{chamber}$.

RESULTS

- *The radial dose distribution being scored by all three detectors with monte carlo simulation is shown in Figure 1. The various vertical lines shows the limit of integration of different detectors due to difference in diameters. Full collection is assumed to be integration through 15 cm radially.*
- *The difference in the radial doses in Figure 1 is attributed to the difference in thickness of the detector which affect the number of ionisation events and thus the dose collected with BPC.*
- *Figure 2 shows the depth-dose curve and the corresponding correction factors for the three different detectors with and without rangeshifters.*
- *PTW TN34070 shows the highest correction factor of ~1.07, needed for both with and without range-shifter in Figure 2.*
- *Generally, the highest correction factors arise at the middle plateau region of the pristine Bragg peak. We have determined this is due to the nuclear particles from the non-elastic interaction.*
- *The correction factor with rangeshifter has a high value at the entrance of the beam. This could be potentially due to the contamination effect from the range shifter.*

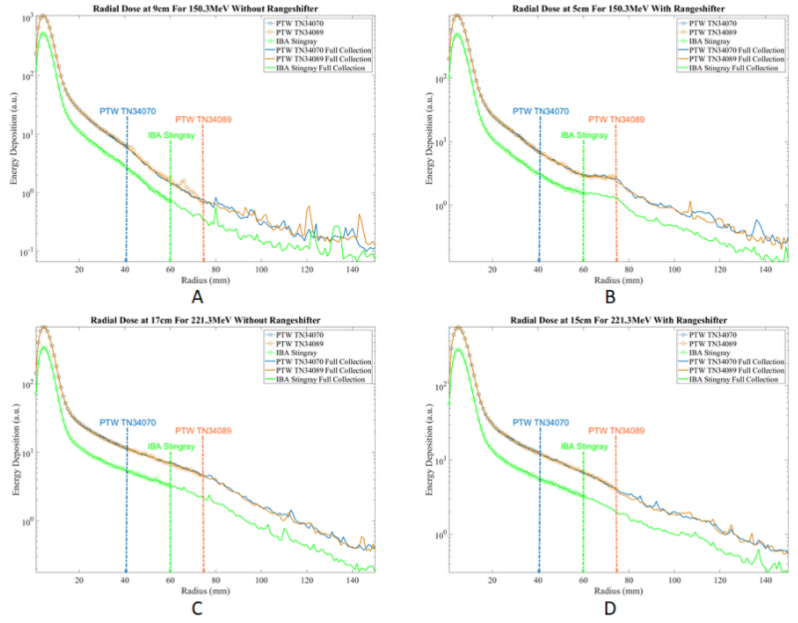

Figure 1: A to C and D to F shows the correction factors for detectors PTW TN34070, PTW TN34089, and IBA Stingray respectively without and with range-shifters respectively. The IDD curves represents the energy 100MeV, 150.3MeV and 221.3MeV respectively

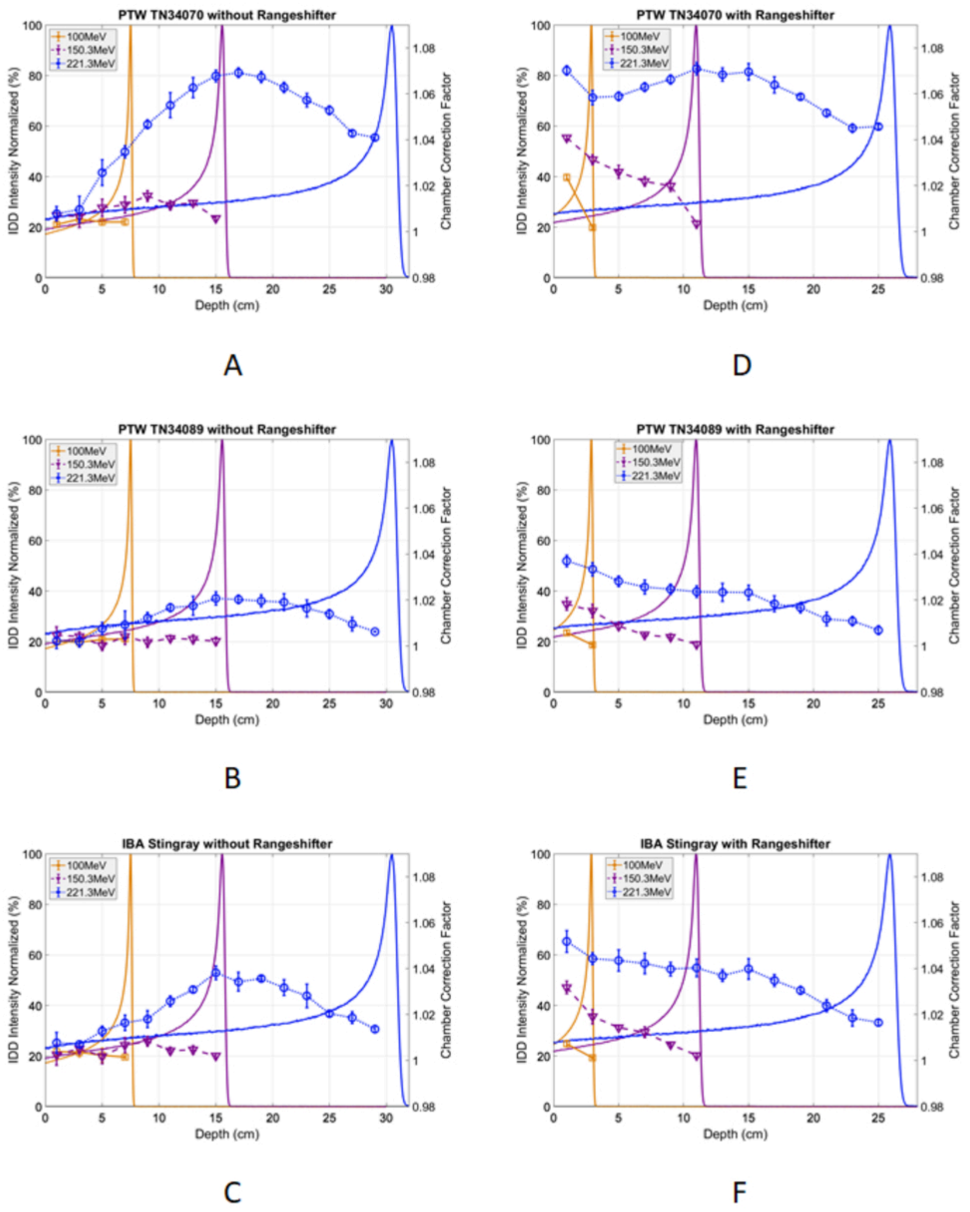

Figure 2: A and C shows the radial plot scoring at the depth where the highest correction factors are at 150.3MeV and 221.3MeV without and with range-shifter

CONCLUSIONS

PTW TN34070 has the highest correction factor of 7% as the size of detection area is the smallest among the three detectors compared in all circumstances.

PTW TN34089 has consistently a correction factor of approximately of no more than 3% for open beam and 4% with range-shifter. This is thus the preferred BPC with least correction factors among the three commercial detectors presented in this work.

The dependence on the size of the detectors decreases with decreasing energy as shown in Figure 2.

ACKNOWLEDGEMENTS

None

REFERENCES

1. B. Gottschalk, E. W. Cascio, J. Daartz, and M. S. Wagner, On the nuclear halo of a proton pencil beam stopping in water, Physics in Medicine and Biology 60, 5627-5654 (2015)
2. H. Paganetti, Nuclear interactions in proton therapy: dose and relative biological effect distributions originating from primary and secondary particles, Physics in Medicine and Biology 47, 747{764 (2002)
3. S. Agostinelli et al., Geant4la simulation toolkit, Nuclear Instruments and Methods in Physics Research Section A 506, 250-303 (2003)

CONTACT INFORMATION

tan.hong.qi@nccs.com.sg