Comprehensive evaluation and implementation of two independent methods for beam monitor calibration for proton scanning beam

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

INTRODUCTION

The proton pencil beam scanning monitor unit is typically calibrated with a large uniform field and an ionization chamber for point dose measurement. An alternative method is to measure a single-energy beamlet with large diameter (e.g. > 80 mm) Bragg peak chamber (BPC). However, one obvious limitation of the latter method is to get an accurate calibration coefficient for BPC. How to perform this task was only briefly mentioned in literatures without sufficient details. For such a large sensitive area BPC, the heterogeneity of both the calibration field and the chamber response over the large active area must be taken into account.

AIM

The purpose of this work is to clinically implement the above-mentioned two methods for proton beam monitor calibration. The advantages, accuracy, and sources of uncertainties of the two methods were comprehensively evaluated and investigated.

METHOD

- Single energy layer circular fields of diameter 15 cm with 2.5 mm spot spacing and 10 times of repainting (FS15cm) were designed for all energies.
- The effective measurement points of Bragg peak chamber (BPC), advanced Markus chamber (AMC) and farmer chamber (FC) were all aligned to 2 cm depth in water using SSD setup.
- The BPC and AMC were cross-calibrated with farmer chamber (FC) using the field FS15cm.
- In order to evaluate BPC's lateral response uniformity, a collimated narrow proton beam (5.8 mm diameter) was delivered to the active area and edge of the BPC.
- The dose area product (DAP) was measured using two methods by two BPCs, one AMC and one FC.
- For method 1, a single spot proton beam was delivered to the geometric center of the BPC.
- For method 2, the fields FS15cm were delivered to FC and AMC, respectively.

RESULTS

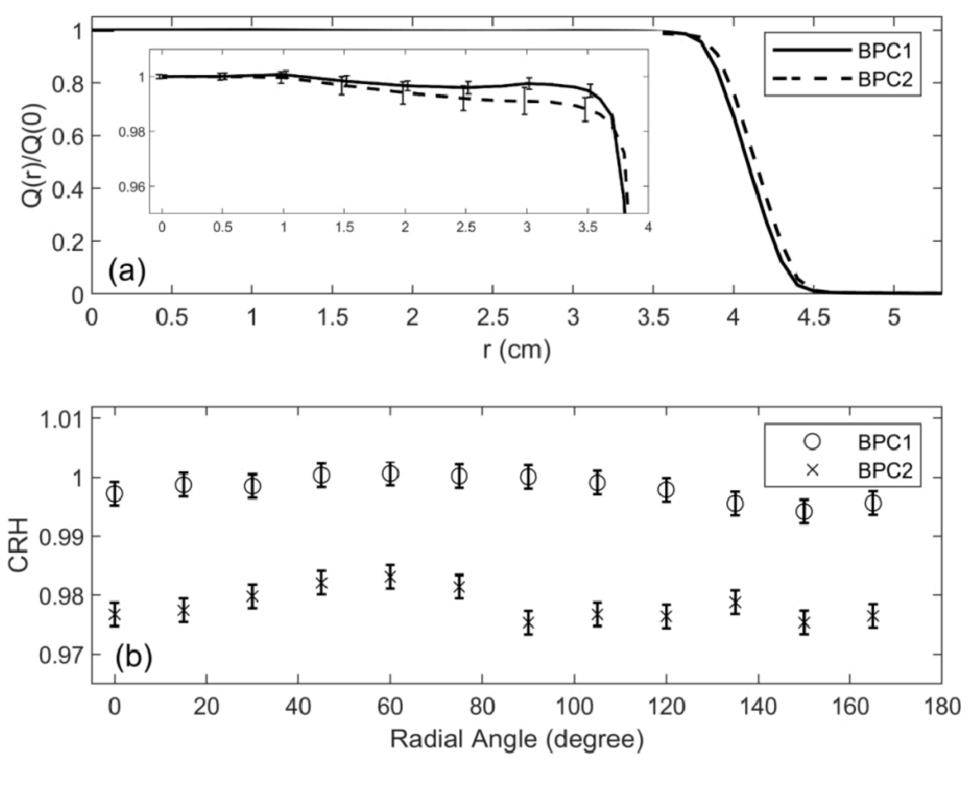

Figure 1: (a) Lateral response curves for BPC1 (solid curve) and BPC2 (dashed curve). The inserted figure is a zoom in of the lateral uniformity and the associated standard deviations. An offset of 0.2 mm was applied to the horizontal axis to avoid overlap in display. (b) The chamber response heterogeneity (CRH) correction factors for all 12 full radial scans are shown for BPC1 (circle symbols) and BPC2 (cross symbols). A 0.2% standard deviation is plotted as the error bar figure.

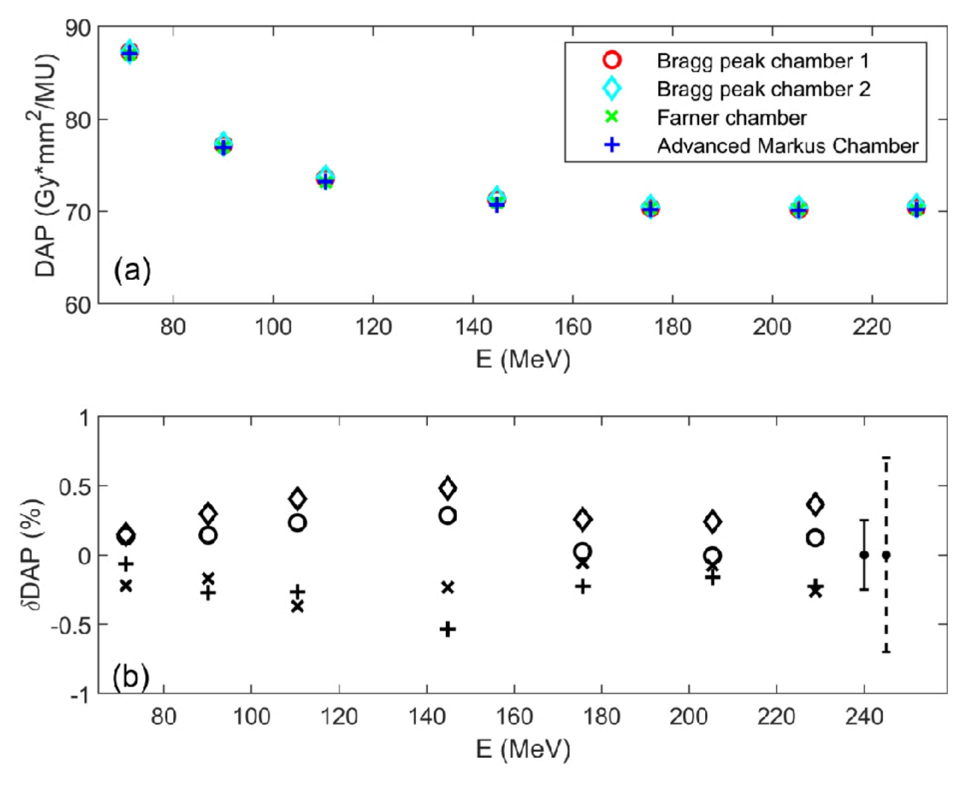

Figure 2: (a) The DAP measured by method 1 with BPC1 and BPC2, and by method 2 with FC and AMC. (b) The percent difference of DAP for all four chambers. The typical type A uncertainty (0.25%) and the combined standard uncertainty (0.7%) are shown in the right of the figure by solid and dashed error bar symbols.

CONCLUSIONS

- When using BPC to measure the DAP of narrow proton spots, the BPC lateral response uniformity should be carefully evaluated.
- Because of the various complex causes of uncertainties in DAP measurements using either method 1 of single spot with BPC or method 2 of large field with FC/AMC, it is recommended to cross check the DAP values with both methods to improve the accuracy of DAP measurements for PBS MU calibration.

ACKNOWLEDGEMENTS

We thank our colleague Dr. Nicholas Remmes for his insightful comments on the manuscript, and for his help for sharing the BPC from his site.

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