

Theme: Physics

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Impact of Field Uniformity Variation on Pencil Beam Scanned Proton Beam Absolute Dose Measurement using Adv. Markus Ionization Chamber

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Background / Aims:

Parallel plane ionization chambers, such as the Adv.Markus chamber, are recommended for determining the absolute dose of pencil beam scanned (PBS) proton beams. However, the small sensitive volume of these chambers may be sensitive to the variations of the uniformity of scanned proton fields, especially in higher energy beams with smaller spot size. A uniform lateral dose profile is essential for accurate absolute dose measurement. However, due to the intrinsic spot positioning uncertainties in PBS system during beam delivery, the actual delivered field may exhibit variations in uniformity, potentially causing fluctuations in dose measurements using Adv.Markus. This study evaluated the impact of field uniformity variation on absolute dose measurement using Adv. Markus ionization chamber.

Subjects and Methods:

Absolute dose measurements were performed for four high energetic pristine beams: 189.8, 200.3, 216.1 and 221.2 MeV. A 10x10cm²single energy layer scanned field was generated by scanning each beam with a spot spacing of 2.5mm. Total 200MU was delivered per field with equal spot weighting. The effective measurement point of Adv. Markus chamber was positioned in the low dose gradient region (6cm in water) of these beams. Measurements were repeated 10 times for each beam without repainting, with 5 and 10 times of layer-repainting, respectively. The relative standard deviation (RSD) of Adv. Markus chamber measurements was calculated as an indication of the measurement fluctuation. The field uniformity variation for these beams with and without repainting was evaluated using a 2D ionization chamber array. Field uniformity variation index was defined as the root mean square of the ratio of the standard deviation to the mean of the readings from 2D array detectors located within an 8x8cm² central field area.

Result:

The RSDs of all ionization chamber measurements are listed in Table 1. Higher RSD values (>1%) were observed for measurements without repainting. The field uniformity variation index of these four beams with and without repainting is illustrated in Figure 1. The field uniformity variation decreased as the number of repainting increased. The RSD of dose measurements using Adv.Markus decreased with increased repainting. By repainting 5 times, all RSD could be reduced to below 0.5%, mitigating the measurement fluctuation to an acceptable level.

Energy (MeV)	Relative Standard Deviation (%)		
	no repainting	5 times repainting	10 times repainting
221.2	1.95	0.19	0.02
216.1	1.53	0.14	0.07
200.3	1.35	0.46	0.07
189.8	1.05	0.43	0.08

Table 1. relative standard deviation of absolute dose measured by Adv.Markus with and without repainting

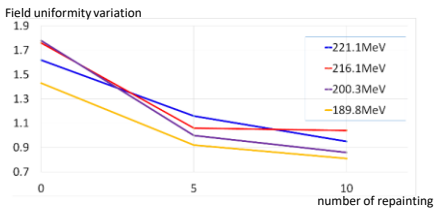


Figure 1. Field uniformity variation vs. number of repainting

Conclusion:

The dose measurements using the Adv.Markus exhibits susceptibility to field uniformity variation, particularly in higher energy beams with smaller spot sizes. Measurement fluctuations could be minimized by delivering the beam with repainting.