An overview of the commissioning of a two-gantry proton pencil beam scanning system

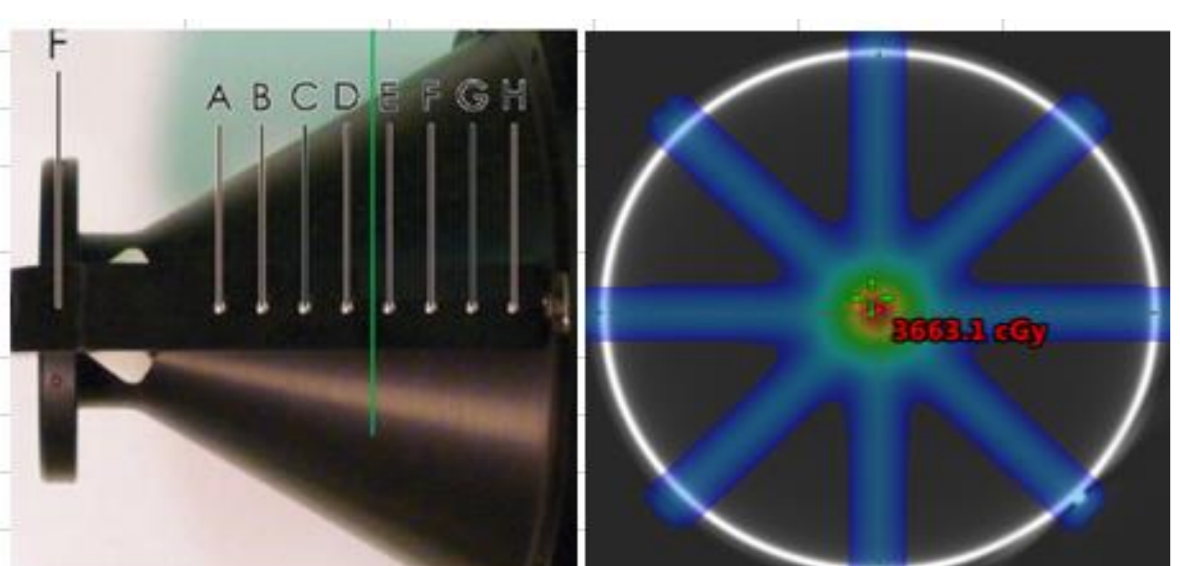
Yongbin Zhang, Eunsin Lee, Zhiyan Xiao, Michael Lamba, Anthony Mascia
University Of Cincinnati, Medical Center. Cincinnati, OH, U.S

Introduction

State-of-art pencil beam scanning (PBS) proton system can deliver highly-modulated fields with high dose rate to arbitrary shaped target. In this work, we report an overview of the commissioning procedure of a two-gantry PBS system. Critical parameters for beam delivery and dosimetry were acquired and validated, and adequate beam matching was established between two rooms.

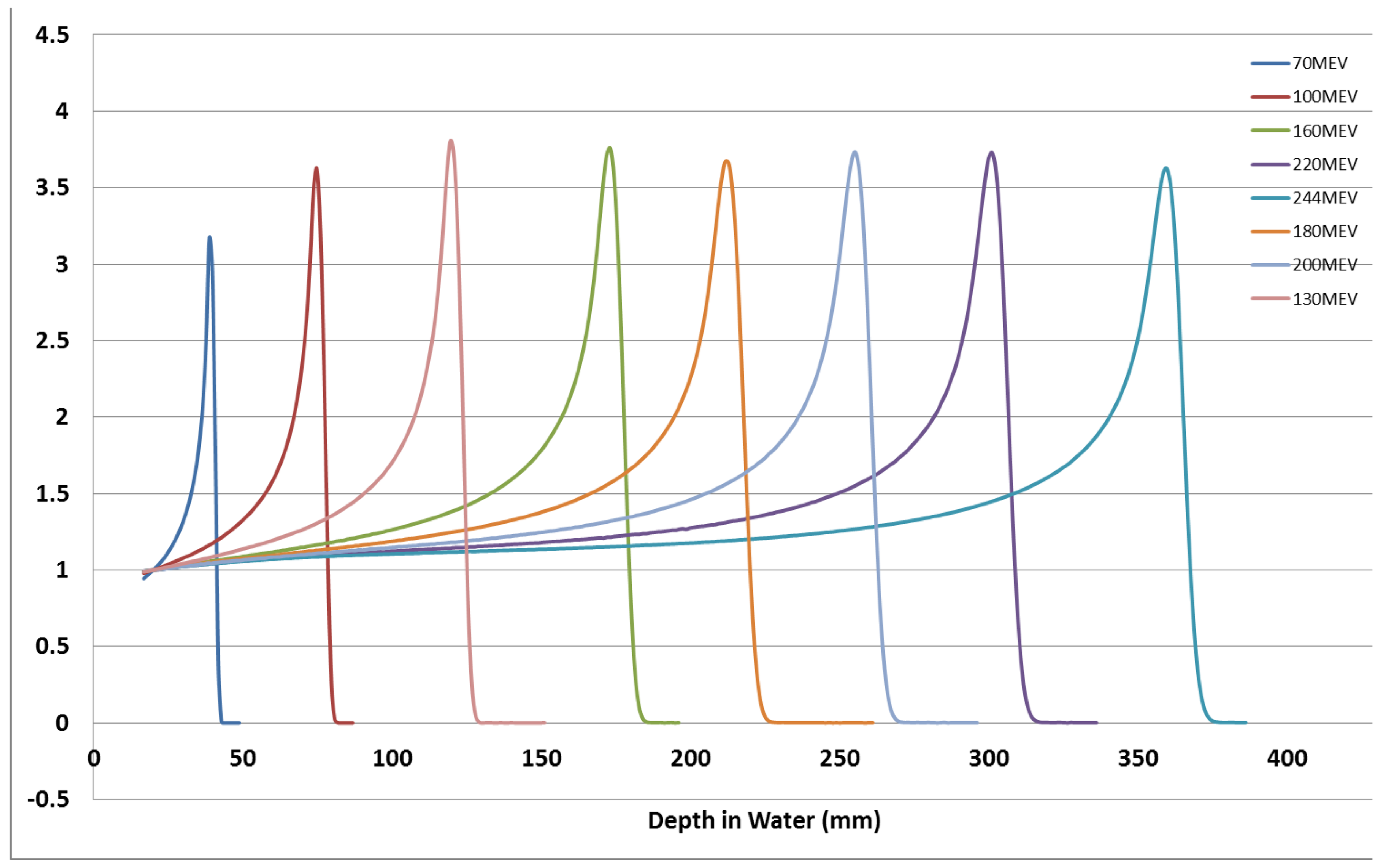
Method and Material

Cincinnati Children's/UC health proton center is equipped with Varian's Probeam system integrated with Eclipse planning system and ARIA information system. The system includes two clinical rooms with 360-degree rotating gantries. It consists of a 250 MEV superconducting cyclotron, an energy selection system, a beam transportation system and a scanning nozzle, which is capable of delivering proton spots ranging from 4 to 36.3g/cm^2 to arbitrary shaped targets over a scanning area of 30x40cm at iso-center. Proton ranges and beam positions were verified at both rooms to ensure accurate beam delivery. All of required dosimetric parameters, including depth dose curves, in-air spot size and dose per monitor unit vs. energy, were then employed to create a beam model in the treatment planning system. Treatment plans with the variable field sizes and depths were delivered for the validation of our beam model accuracy. In addition, beam matching was successfully established and validated between two rooms.



Gantry	X (mm)	Y (mm)	Z (mm)	Distance to Target (mm)
180	-0.35	0.00	79.65	0.40
135	0.37	0.37	79.16	0.60
90	0.00	0.31	79.35	0.32
45	0.20	-0.20	78.84	0.67
0	0.38	0.00	79.22	0.45
315	-0.15	-0.15	79.09	0.42
270	0.00	0.50	79.57	0.52
225	0.03	-0.03	79.52	0.08
Average:	0.06	0.10	79.30	0.19

Figure 1: Beam spot at isocenter at eight angles measured with a cone-shaped scintillator camera.



Energy(MeV)	Spec.	R80	Diff. (mm)
244	363.74	363.07	-0.67
240	353.72	353.08	-0.64
230	329.12	328.62	-0.49
220	305.16	304.55	-0.61
210	281.87	281.41	-0.47
200	259.28	258.70	-0.58
190	237.40	237.02	-0.39
180	216.27	215.86	-0.41
170	195.90	195.57	-0.33
160	176.32	175.93	-0.39
150	157.55	157.15	-0.41
140	139.64	139.03	-0.60
130	122.60	121.96	-0.64
120	106.47	105.75	-0.71
110	91.28	90.60	-0.68
100	77.07	76.49	-0.59
90	63.89	63.25	-0.63
80	51.76	51.20	-0.56
70	40.75	40.20	-0.55

Figure 2: Ranges measured by IBA Stingray Bragg peak chamber.

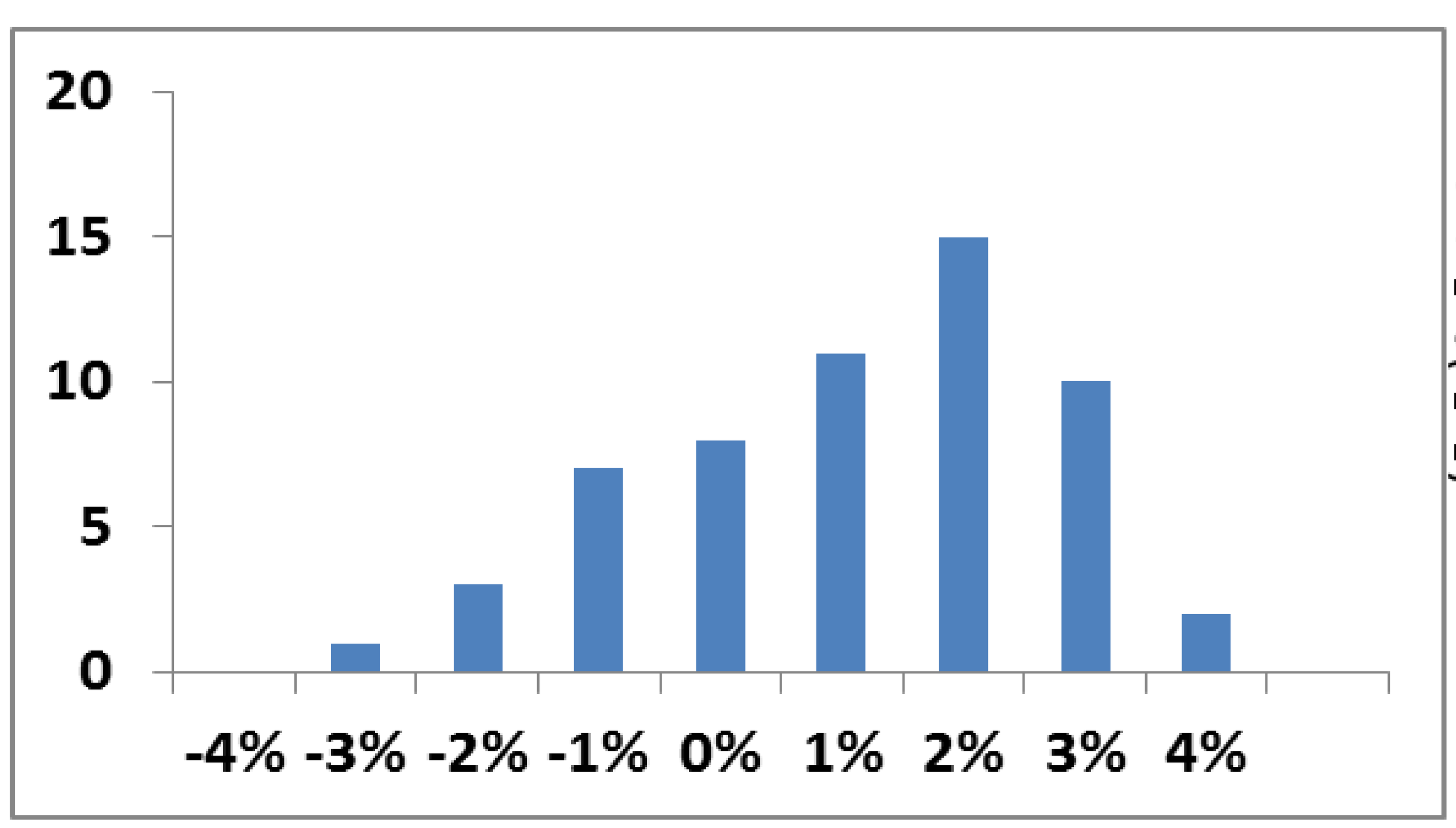


Figure 3: Histogram of % difference between ion chamber measurements of 58 fields and calculations.

Results

The measured ranges were identical in two rooms within -0.5±0.1mm deviations from the specification. The beam position accuracy at isocenter was within 0.5mm for each of the eight gantry angles. For the validation plans, the average dose difference was -0.7%±1.6% for 58 fields within target regions. In particular, for small fields, the measurements were ~2% lower than calculations; but for fields with 5.7cm-WET range shifter, the measurement were ~2% higher than calculations. With up to 15% measured in-air spot size variations between two rooms, the output difference was -0.5±1.3% for 34 fields measured in both rooms.

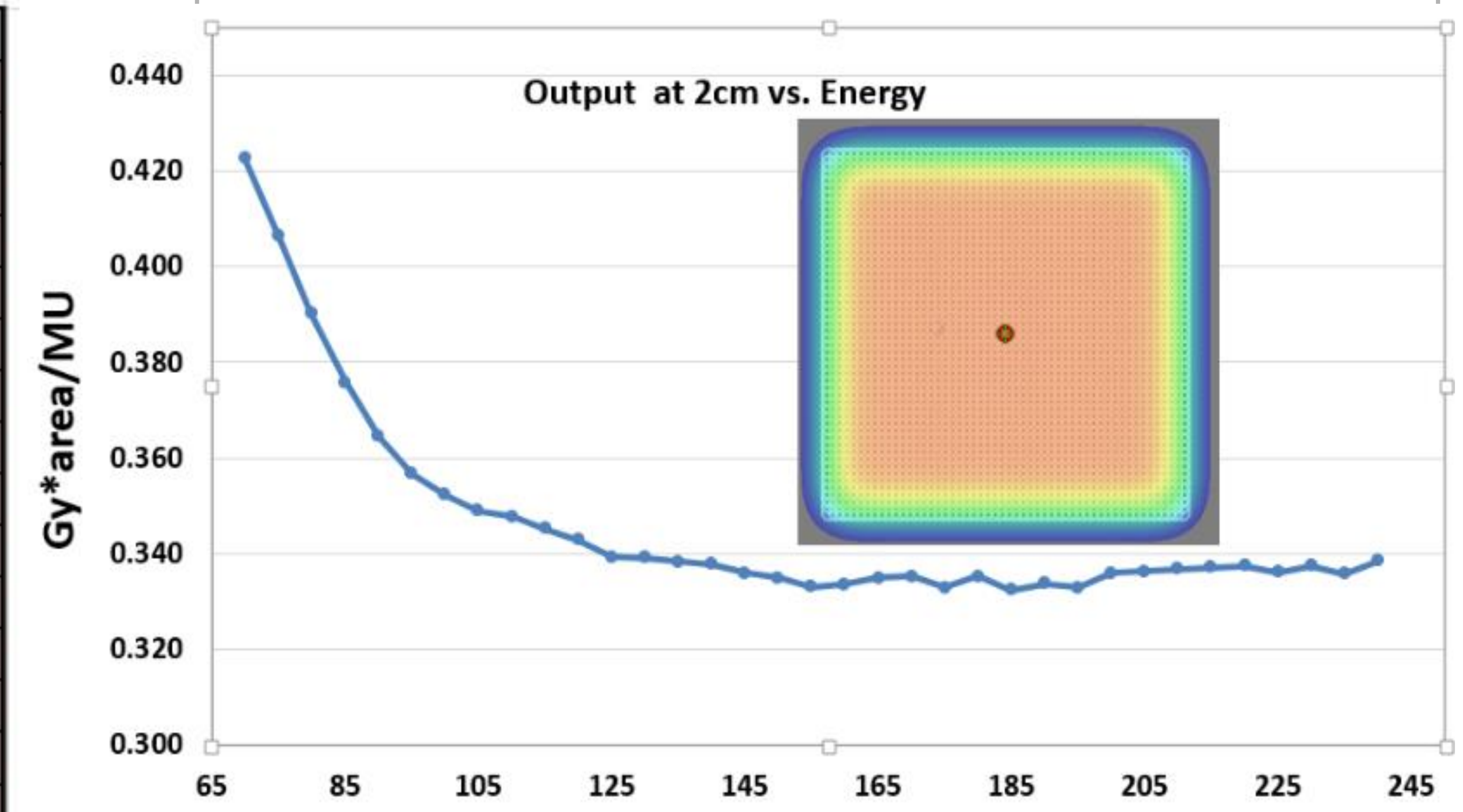


Figure 3: Absolute output measured with PTW advanced Markus chamber at 2cm depth of 10x10cm of a flat field to derive integrate dose per MU.

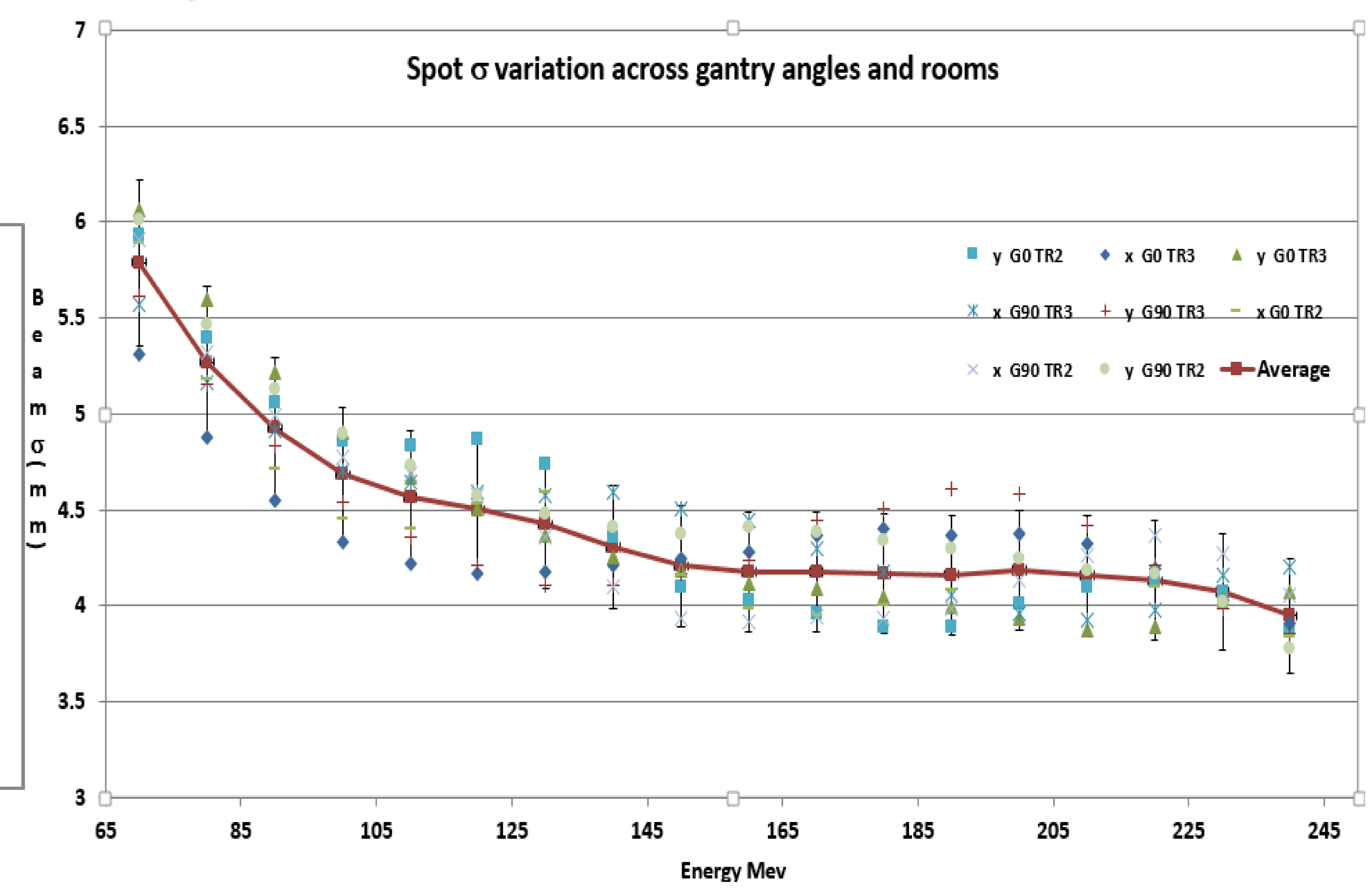


Figure 5: Spot size variations at different gantry angles in two rooms, the error bars show up to 15% beam specs.