2026 JOINT AAPM | COMP MEETING
JULY 19–22 | VANCOUVER, BC

Gantry Dependent Transient Output Variation in a Compact Synchrocyclotron Proton Therapy System

Akbar Anvari, Kai Yang, Madison Mckinnon, Sheanna Allen, Carnell Hampton
Department of Radiation Oncology, Proton & Advanced Radiation Center, Atrium Health Levine Cancer Institute, Charlotte, NC

Atrium Health
Levine Cancer Institute

Abstract

To evaluate transient output variation immediately following gantry rotation in a compact synchrocyclotron-based proton therapy system, with focus on quantifying magnitude of output deviation between initial post-rotation measurement and subsequent stabilized measurements and assessing how this deviation depends on gantry angle.

Introduction

This study presents a systematic, multi-angle evaluation of transient output variations in a compact synchrocyclotron-based proton therapy system, a phenomenon that has not been extensively quantified in clinical practice. By focusing on the first post-rotation beam output as first-shot relative to subsequent stabilized measurements across multiple gantry angles, this work provides a novel framework to assess angle-dependent output dynamics immediately following gantry motion. The approach combines longitudinal data collection over six months, high angular resolution (nine gantry positions from 0° to 180°), and statistical characterization of transient behavior, offering a quantitative and reproducible methodology for understanding short-term output deviations in compact proton therapy systems. This framework could inform both clinical QA procedures and future engineering studies aimed at optimizing synchrocyclotron beam stability.

Methods and Materials

Nine gantry angles from 0° to 180° in 22.5° increments were evaluated over a 6-month period on a Mevion S250i synchrocyclotron system. At each angle, four consecutive output measurements were acquired using a consistent setup. First measurement was designated as first-shot value to represent beam output immediately after gantry rotation. The subsequent three measurements were averaged to represent stabilized output at that angle. For each angle, difference between first-shot value and stabilized average was calculated, along with corresponding upper and lower extrema, mean, and standard deviation of transient behavior.

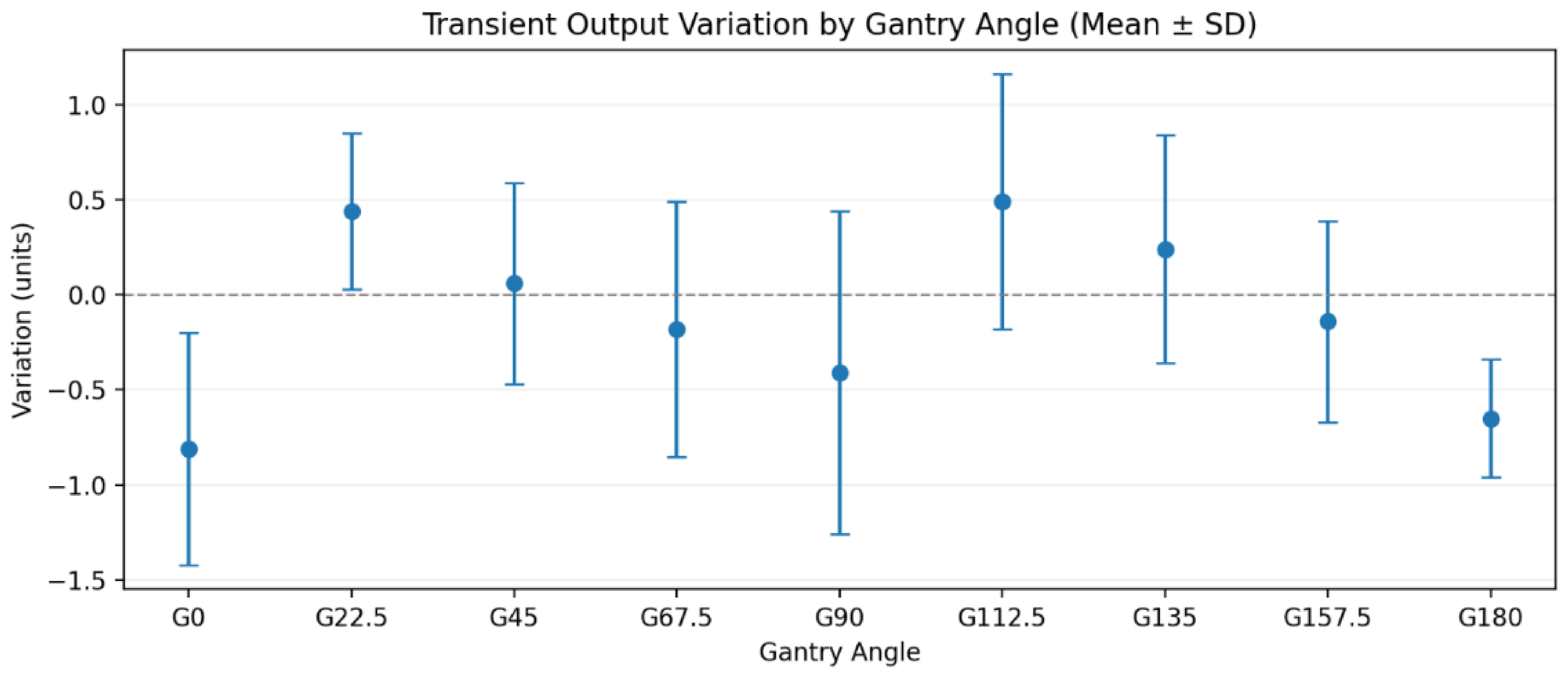

Figure 1 . Transient output variation by gantry angle.

Results

The three stabilized measurements at each gantry angle showed reasonable repeatability, indicating stable output once gantry settled. In contrast, first-shot measurement differed from stabilized average by up to 1.96%, observed at G90. The magnitude of this first-shot deviation was angle-dependent where over 6-month evaluation, 7/9 angles exhibited first-shot differences that exceeded 1%, while all stayed within 2%. The largest mean first-shot biases over 6-month period were observed at G0 and G180 with -0.8% and -0.65 respectively, and standard deviation across angles was approximately 0.5%.

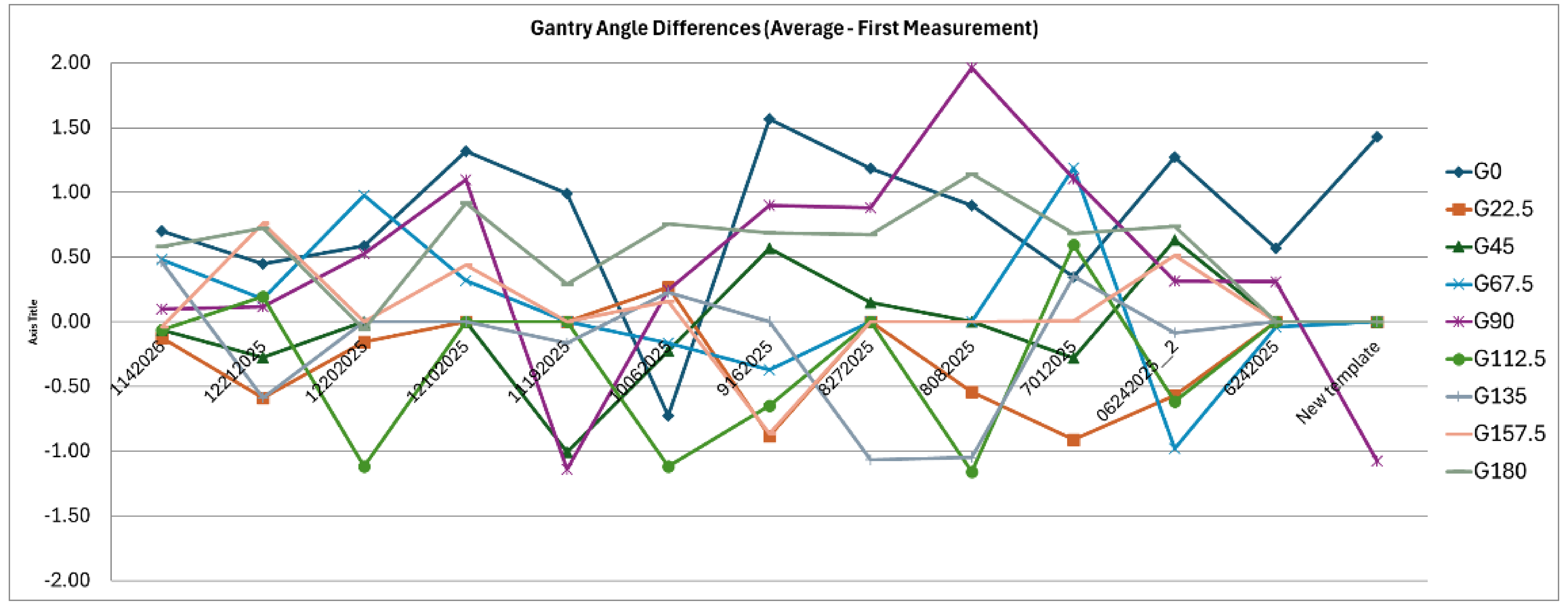

Figure 2 Output at different angles.

Conclusions

This work quantifies an angle-dependent transient output effect occurring immediately after gantry rotation in a compact synchrocyclotron-based proton therapy system. While stabilized output demonstrated reasonable stability, first-shot value consistently differed from stabilized average, with magnitude varying by gantry angle and remaining within a 2% tolerance. These findings establish a quantitative foundation for understanding transient output variation in this system and may support future investigations into clinical and engineering implications, although such interpretation was beyond scope of this study.

Contact

Akbar Anvari, MSc, PhD, DABR
Department of Radiation Oncology, Proton & Advanced Radiation Center, Atrium Health Levine Cancer Institute, Charlotte, NC
Email: Akbar.Anvari@advocatehealth.org
Phone: 980-442-3438