# Integration and Testing of Dynamic Collimation System Controller for Pencil Beam Scanning Proton Therapy

**Kaustubh A. Patwardhan[1], Theodore Geoghegan[1], Ryan Flynn[1], Daniel Hyer[1]**

[1]Department of Radiation Oncology, University of Iowa, Iowa City, IA 52242

## INTRODUCTION

- The accuracy of radiation dose delivery for Pencil Beam Scanning (PBS) Proton Therapy (PT) using a Dynamic Collimation System (DCS) depends on the precise and automatic positioning of multiple trimmer blades
- The integration of the DCS controller with the mechanical assembly and the clinical IBA (Louvain-La-Neuve, Belgium) system overcomes this challenge
- The controller precisely positions four trimmer blades within a required tolerance of ±0.5 mm before each spot delivery for PBS-PT to maximize the improvement in lateral dose falloff

## METHOD

- A DCS prototype was built consisting of two pairs of orthogonal nickel trimmers moved by linear motors **(Figure 1)**
- The motors were interfaced with the DCS controller using ACS Motion Control (Yokneam Illit, Israel) software **(Figure 2)**
- The DCS controller was interfaced with the real-time IBA scanning controller using the analog input/output (I/O) modules of the DCS controller
- The interface was tested and verified by the IBA scanning controller providing set-points to the DCS controller in the form of trimmer positions and receiving real-time feedback on the actual trimmer positions
- Motors were stress-tested and characterized for their speed and positional accuracy to identify the latency of the DCS

### DCS Model and Prototype

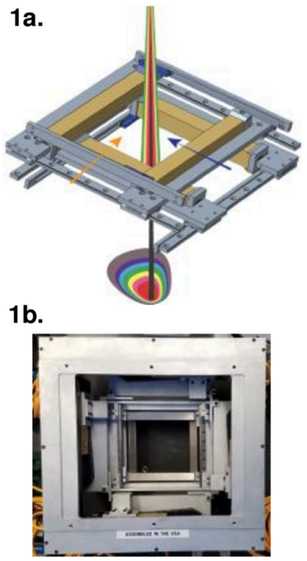


**Figure 1: a. DCS Model (Geogheghan et al., Medical Physics, 2020), b. DCS prototype**

### DCS Integration


**Figure 2: DCS controller interface with the DCS mechanical assembly**

## RESULTS

- Positional accuracy of the system was verified using a FaroArm Laser Scanner (Lake Mary, Florida)
- Maximum values of motion parameters that resulted in a system that could be tuned to be critically damped were found to be: velocity = 3000 mm/s, acceleration = 40000 mm/s$^2$ and jerk = 50000 mm/s$^3$
- The prototype DCS controller was shown to position the trimmers within the required tolerance level (±0.5 mm) prior to beam delivery with an accuracy of ±0.035 mm
- Latency of the DCS controller was found to be 0.6 ms

### DCS Positional Accuracy Verification

| Stroke Length (mm) | Measured Stroke Length (mm) | Difference (mm) |
|---|---|---|
| 1 | 0.9654 | 0.0346 |
| 2 | 2.0133 | 0.0133 |
| 5 | 5.0055 | 0.0055 |
| 10 | 9.9917 | 0.0083 |
| 20 | 20.0153 | 0.0153 |
| 40 | 39.9824 | 0.0176 |

**Table 1: Positional accuracy verification using FaroArm**

### DCS Trimmer Motion Profiles

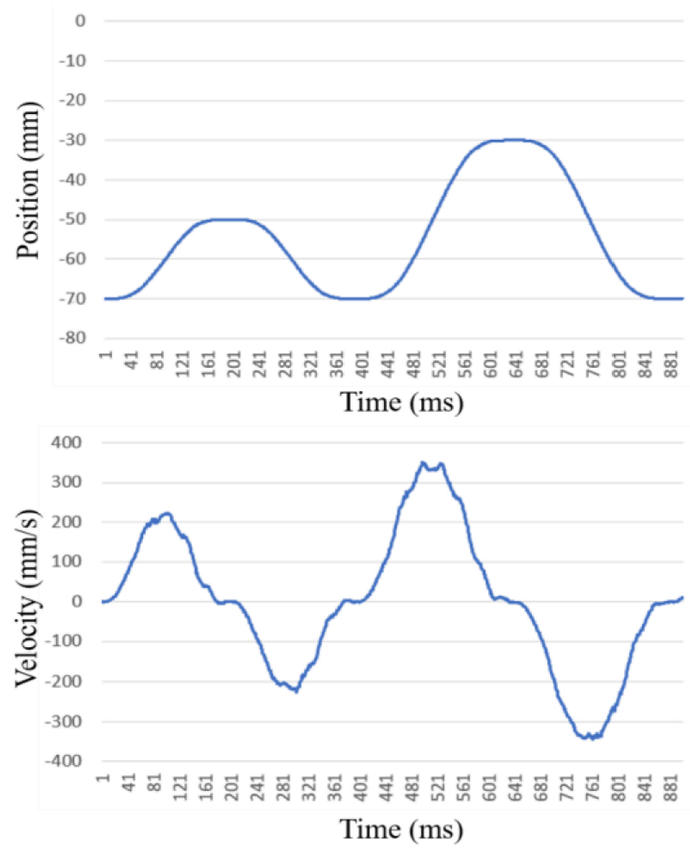


**Figure 3: Trimmer motion profiles for two stroke lengths of 20 mm and 40 mm at JERK = 50000 mm/s$^3$**

## CONCLUSIONS

- The DCS controller can be successfully integrated with a commercial IBA Pencil Beam Scanning Proton Therapy system
- The DCS controller can be used to accurately and automatically position the trimmers for treatment delivery, ultimately improving dose conformity

## ACKNOWLEDGEMENTS

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## REFERENCES

- Geogheghan et al., Design of a focused collimator for proton therapy spot scanning using Monte Carlo methods, Medical Physics, 2020.

## CONTACT INFORMATION

Kaustubh A. Patwardhan, kpatward@healthcare.uiowa.edu