A systematic log file analysis tool for the Mevion S250i Hyperscan system: First year experience

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INTRODUCTION

- Our Mevion S250i Hyperscan pencil beam scanning proton system was commissioned in January 2019 and we have treated ~190 patients since then.
- At the beginning of each treatment day, therapists run a daily QA plan consisting of 3 beams: a warmup beam with uniform spot and dose spacing, a spot position check to fully cover the maximum field size, and a dose check for daily output measurements.
- The Hyperscan system records all relevant treatment parameters in log files for offline analysis.

PURPOSE

- Based on the machine log files for each daily QA, a Matlab script was developed to analyze machine performance in the daily QA plans for the first year of use.
- The code developed here will be applied to the log files from our first year of patient treatment.

METHODS

- A Matlab script (version 2018b) was developed to read batches of log files. For each log file, the script computes the distance between the planned and measured position of each beam spot, as well as the difference between each spot's planned and measured MU.
- The spot position and MU errors, and log file date were all recorded for analysis.

RESULTS

- Major maintenance took place in May and June 2019, and a major software update took place in September 2019. Significant changes are seen in the daily QA data corresponding to those dates in Figures 1 and 2.
- The September 2019 software update improved beam steering and implemented an improved method to calculate spot position. The results of these changes can be seen in Figure 3, where the spot position errors before and after the upgrade are shown in a histogram.

Figure 1: Mean spot position errors (top) and mean delivered MU errors (bottom) for the daily spot position check beam. Error bars represent the standard deviation of the mean. The spot position errors before and after the September 2019 software update correlate with the data shown in Figure 3.

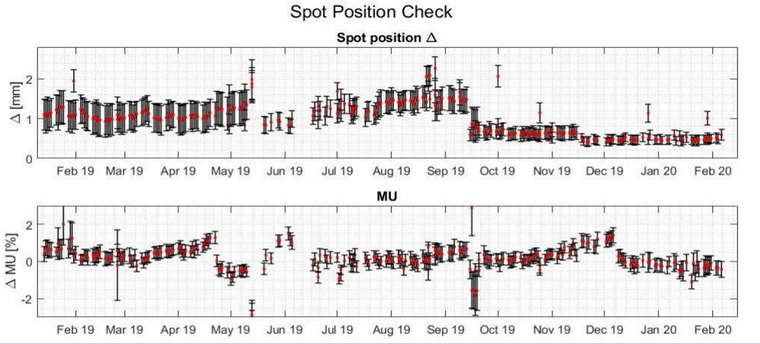


Figure 2: Mean spot position errors (top) and mean delivered MU errors (bottom) for the daily dose check beam. Error bars represent the standard deviation of the mean.

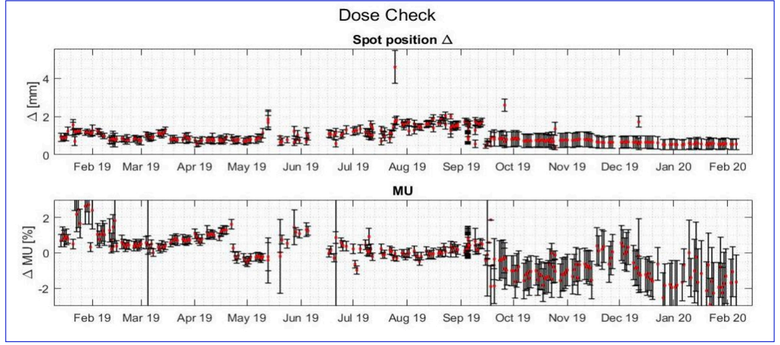
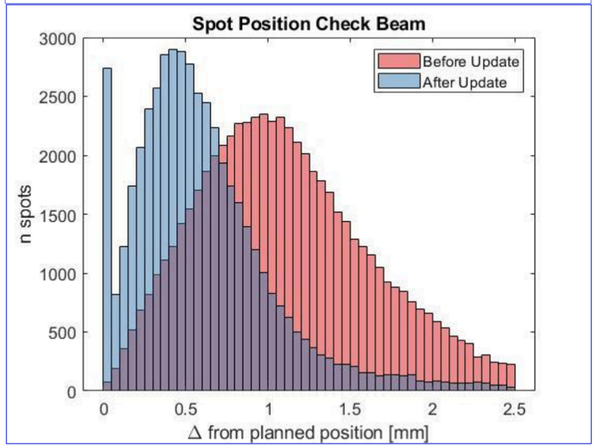


Figure 3: Histogram of spot position errors in the spot position check beam before and after the major software update in September 2019. This data corresponds to the top plot of Figure 1. After the update, the mean spot position error decreased, and so did the spread of errors. This trend is seen in Figure 1 as well.



FAST FIGURES

- The mean spot position error for all beams in the daily QA plan was 0.850 mm, and the mean MU delivery error was -0.335 MU.
- 1.01 $\times 10^6$ spots were cumulatively delivered in the daily QA plans. Of these, 83.2% were within 1.5 mm of their planned position and 94.4% were within 0.2 MU of the planned MU.
- After the latest software update in September 2019, the mean spot position error for the spot check beam was 0.61 mm (σ=0.46 mm)
- After the September 2019 software update, the mean MU error for the dose check beam was -1.1% (σ=2.4%) and 81.7% of delivered spot MUs were within ±3% of planned MUs.

CONCLUSIONS

- We developed a systematic tool for analyzing multiple machine log files for the Mevion S250i Hyperscan system.
- Spot position errors and MU delivery errors are clinically acceptable.
- Our log file analysis code is currently being applied to all patient treatments during the first 15 months of our proton machine's operation. A retrospective study of machine performance will be published in forthcoming publications.

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