Purpose:To develop a fast Monte Carlo code dedicated to a new hybrid imaging-treatment modality, the MRI-Linac, involving the irradiation of a patient in the presence of a strong magnetic field (MF). These conditions require a dose calculation engine capable of coping with the effect of the MF on the dose distribution during the planning stage. It is not likely that analytical solutions such as pencil beams calculations can be efficiently adapted for dose calculations within a MF. Monte Carlo simulations seem more appropriate but are typically too slow for a routine clinical utilization, let alone an online image-based replanning approach.

Methods:GPUMCD, a fast GPU-based Monte Carlo dose calculation platform, was adapted to handle dose calculations within a magnetic field. The code was benchmarked and validated through comparisons with experimental measurements in two cases where large magnetic field induce significant dose effects at air-tissue interfaces. The validation also included a timing benchmark in a clinically representative prostate case to evaluate if online dose calculation is possible.

Results:GPUMCD was found to produce accurate dose distributions, according to a 2%-2mm gamma analysis, when compared to experimental measurements. Furthermore, execution times of less than 0.4 seconds were achieved for one beam in a prostate case phantom for a 2% statistical uncertainty while 0.8 seconds are required for a 7 beams plan having the same uncertainty.

Conclusions:These results suggest that GPUMCD is an interesting candidate for dose calculations for a hybrid MRI-Linac modality. Its accuracy has been validated against experimental measurements and its speed let envision online replanning based on changes in anatomy found at the time of treatment.