**ABSTRACT SUBMISSION FORM**

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**PRESENTATION TITLE**

Error estimation of slice chipping effects due to gradient non-linearity on the MR-Linac

**AUTHOR(S)**

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**ABSTRACT**

Purpose:

Hybrid MR-Linac systems are able to monitor the anatomy and adapt the radiation treatment in real-time, by tracking tissue on continuously acquired 2D MR images. The spatial encoding of MRI relies on linear gradient fields. Non-linear components of these fields inherently result in distorted images. Accordingly, the non-linearity of each magnet design is modelled and taken into account by the reconstruction software. This non-linearity correction warps the distorted image back to the undistorted image based on the known non-linearity coefficients. For 2D imaging this can only be applied in-plane, since inherently no out-of-plane data is available. Therefore, a 2D image is not sampled from a straight but a curved plane, an effect known as 'potato chipping'.

Here we quantify the slice chipping effect for an MR-Linac system and show that it can be modelled accurately. Furthermore, we characterize the expected through-plane error, which is spatially-dependent. Moving tissue therefore experiences varying errors depending on its current position. This error estimation is helpful to judge the tracking quality for online applications, and could be used for robust slice positioning or incorporated in 4D motion models used for dose calculation.

**Materials & Methods**:

All experiments were performed on a clinical prototype of the 1.5T MR-Linac (Elekta Unity, Elekta AB, Sweden). The phantom used for imaging was a 2% agar solution with an embedded rectangular grid (The LEGO Group, Denmark). The 2D imaging sequence was a spoiled gradient echo sequence with 2mm slice thickness.

Coronal and sagittal slices were acquired interleaved, such that the sagittal slice was visible as a saturation band on the coronal slice. By observing this band the sagittal slice chipping could be measured.
To validate the observed slice chipping, the actual slice positions were simulated with a spherical harmonics expansion, using coefficients extracted from the scanner’s hardware parameters. This was used to transform an ideal straight slice profile to an actual curved slice profile. This was done for two slices that only differed in CC position (+5cm).

Secondly, we introduce an error map to easily judge the quality of slice positioning in tissues underlying motion. Accordingly, the grid was moved in the MRI (10cm in RL-direction). The respective images were overlaid with a color wash indicating the through-plane errors due to field distortions.

Results:
The coronal slice with overlaying through-plane error map is shown in figure 1. The green line denotes the 2mm error iso-line. The fact that the grid remains straight, shows that the in-plane non-linearity correction works well. The through-plane error accurately follows the error iso-lines predicted by the model.

Figure 2 shows two cases where the sagittal slice was shifted in-plane (+5cm CC). In reaction, however, the excited slice also shifted through-plane, correcting the slice center for the local gradient non-linearity.

Conclusion:
The results show that it is possible to predict the slice chipping already in the planning phase, and that the actual slice center is corrected such that it matches the planned location. These are preliminary results and a further quantitative analysis will follow.