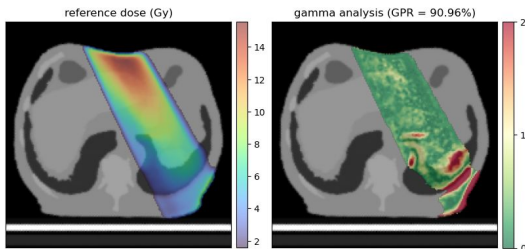


## Introduction and Context

MR-guided radiotherapy systems (e.g. Elekta Unity) enable online adaptive workflows, requiring fast and reliable secondary dose calculation (SDC).

Monte Carlo (MC) methods accurately model the Electron Return Effect<sup>1</sup> (ERE), but their statistical uncertainty limits their use for SDC. In contrast, Collapsed Cone Convolution (CCC) is fast, only accounts for the effects of magnetic field in homogeneous media using a specific warped kernels, leading to false positives when compared to MC-based TPS doses.

In this work, we propose a deep learning-based correction of CCC dose distributions, aiming to combine the speed of CCC with the accuracy of MC in the presence of a magnetic field.



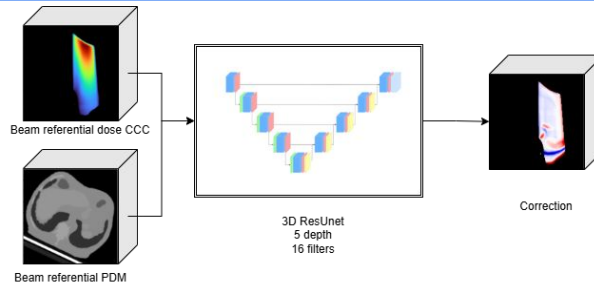
ERE: the magnetic field bends electron trajectories back to tissue interfaces, increasing local dose and leading to reduced gamma pass rates (GPR) and causing false positives.

<sup>1</sup>Raaijmakers AJE et al., Phys Med Biol, 2008.

## Strategy

- ERE depends on surrounding patient geometry → 3D model
- Beam dependence → per-beam learning in beam coordinates
- CCC provides a strong baseline → learn a correction factor  $R_{dnn}$  per voxel

$$R_{dnn} = D_{MC} / D_{CCC}$$



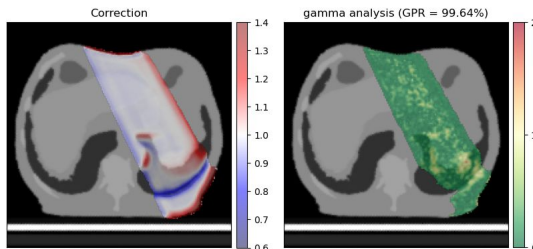
A 3D ResUNet takes beam-aligned CCC dose and patient density matrix (PDM) as inputs to predict a correction toward MC reference.

### Training data:

- 1384 beams
- 2 institutions
- 27 unique patients
- ERE intensive localizations
- MC reference: Monaco
- CCC: ThinkQA DOSIsoft
- 80/20 train/validation

## Results

The performance of the model was evaluated using 3D gamma analysis (2% / 2mm).

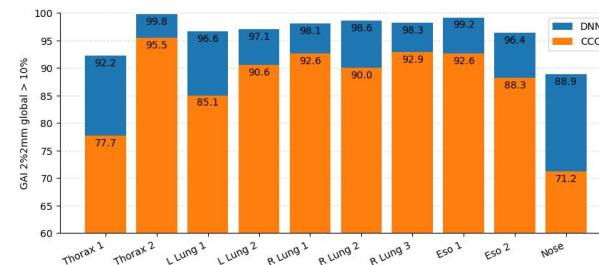


Correction is concentrated in ERE-prone regions: local deviations exceeding 40% (left), increased gamma passing rates (right).

Across all explored localizations, the model restores an accurate ERE, increasing significantly the agreement with the MC reference

## Generalization

Performance was further evaluated on an independent cohort (different institution and beam modelization) to assess robustness and generalization.



Consistent gamma pass rate improvement on an independent cohort: most plans meet the 95% GPR criterion after correction.

## Conclusions: clinical impact

- ✓ Reduces ERE-driven gamma failures
- ✓ Reduces false positives
- ✓ Preserves CCC computation speed
- ✓ Generalizes across institutions and localizations