Karlsruhe Institute of Technology

Institute of Biomedical Engineering

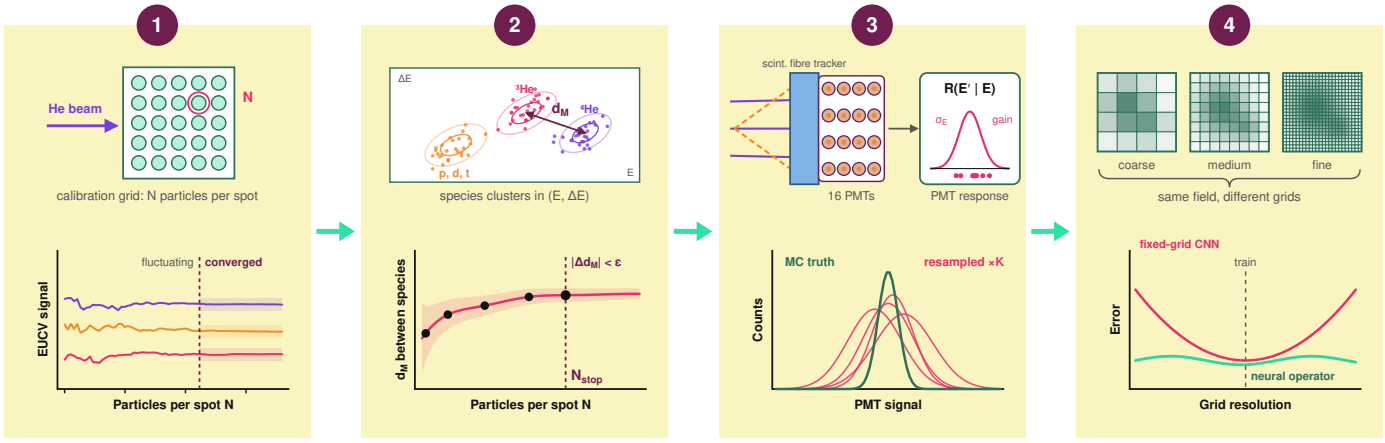
Designing a Training Dataset for Neural-Operator Fragment Removal in Helium CT: Statistical Sufficiency and Physics-Aware Augmentation

Master thesis

Motivation

Helium computed tomography is an experimental imaging technique that provides high-resolution, low-dose images for various applications in ion beam therapy, including treatment planning, verifying patient positioning, and managing motion. Recently, the concept of simultaneous helium imaging during carbon ion radiotherapy (CIRT) was proposed, offering new possibilities for real-time adaptive CIRT.

However, this approach presents significant challenges due to the presence of high-energy fragments generated by the helium beam. These fragments are detected by the imaging system, which degrades image quality and limits the benefits of helium-based imaging. As these fragments have comparable energies to primary ions but unpredictable trajectories, standard filtering techniques are often ineffective. In this context, deep learning (DL) approaches offer a promising solution.



Convergence assessment
(EUCV vs particles per spot)

Mahalanobis stopping criterion
(fragment species separation)

Data augmentation: detector response resampling

Data augmentation: discretization
(for neural operators)

Part I · Statistical sufficiency of the dataset

Part II · Physics-aware data augmentation

Student Project

The performance of learned fragment removal is limited by the quality of its training data: this thesis first determines how many primary particles per calibration spot are needed to characterize the fragment contribution reliably, and then extends the dataset through physics-aware detector augmentation and discretization variation, so that neural operators generalise across detector responses and grid resolutions.

Notes

Application documents: Curriculum vitae and transcript of records

Research Area

Life Sciences, Medical Physics, Deep Learning.

Course of Studies

Biomedical Engineering, Electrical Engineering, Mecatronics and Computer Science

Starting Date

As soon as possible

Posted Date

13.11.2026

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