Project Proposals for Doctoral Researcher Positions 2025

ID03: Fragments filtration for helium radiography and computed tomography (Francesca Spadea, Oliver Jäkel)

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Helium radiography and computed tomography are experimental imaging techniques capable of providing high-resolution, low-dose images for various applications in ion beam therapy, including treatment planning, patient positioning verification, and motion management. Owing to their fundamental properties, helium ions exhibit low scattering and can produce metal artifact–free images. Recently, the concept of simultaneous helium imaging during carbon ion radiotherapy (CIRT) has been proposed, offering new possibilities for real-time adaptive CIRT.

However, this approach presents significant challenges due to the presence of high energy fragments generated in helium and especially in mixed carbon-helium beams. These fragments are detected by the imaging system and degrade image quality, limiting the benefits of helium-based imaging. Because these fragments can have energies comparable to primary ions but follow unpredictable trajectories, standard filtering techniques are often ineffective. In this context, deep learning (DL) approaches offer a promising solution. DLbased methods have already demonstrated success in various radiotherapy imaging applications, such as synthetic CT generation from MRI and CBCT, which are crucial for adaptive radiotherapy workflows. The application of DL techniques could enable effective filtration of high energy fragments, allowing only primary helium ions to be used for image reconstruction.

This project lies at the intersection of data science, particle physics, and life sciences, offering advancements that could benefit all three domains.

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