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AI and Monte Carlo Particle Transport in Medical Imaging and Radiotherapy

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Monte Carlo particle transport is a cornerstone of simulation in medical imaging and radiotherapy, but its computational cost can limit its use. Artificial intelligence offers several routes to accelerate these simulations, from denoising low-statistics results and predicting dose distributions to learning detector responses and generating particle phase spaces.

This talk surveys these approaches through medical applications, including nuclear imaging, radiotherapy dose calculation, and optical photon transport in radiation detectors. It examines what each model learns, which parts of the simulation it replaces, and how its output can be validated. Particular attention is given to the distinction between reproducing an average response and preserving the probability distributions and correlations needed for reliable simulation.

The discussion also extends to AI-assisted radiotherapy planning, where a predicted dose distribution must be converted into a physically deliverable treatment plan. Together, these examples highlight the opportunities for combining AI with Monte Carlo methods and the importance of evaluating the complete workflow, beyond prediction accuracy or computational speed alone.

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