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Abstract for an Invited Paper  
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**The use of Monte Carlo methods in heavy charged particle radiation therapy.<sup>1</sup>**

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This presentation will demonstrate the importance of Monte Carlo (MC) simulations in proton therapy. MC applications will be shown which aim at 1. Modeling of the beam delivery system. MC can be used for quality assurance verification in order to understand the sensitivity of beam characteristics and how these influence the dose delivered. 2. Patient treatment dose verification. The capability of reading CT information has to be implemented into the MC code. Simulating the ionization chamber reading in the treatment head allows the dose to be specified for treatment plan verification. 3. 4D dose calculation. The patient geometry may be time dependent due to respiratory or cardiac motion. To consider this, patient specific 4D CT data can be used in combination with MC simulations. 4. Simulating positron emission. Positron emitters are produced via nuclear interactions along the beam path penetration and can be detected after treatment. Comparison between measured and MC simulated PET images can provide feedback on the intended dose in the patient. 5. Studies on radiation induced cancer risk. MC calculations based on computational anthropomorphic phantoms allow the estimation of organ dose and particle energy distributions everywhere in the patient.

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