

The Monte Carlo method is considered to be the most accurate method to simulate absorbed dose in radiation therapy. Due to the increase in computer power, there is no doubt that Monte Carlo will be the dominant dose calculation method in the near future. The impact of Monte Carlo dose calculation could potentially be bigger in proton therapy than in conventional radiation therapy due to the highly conformal dose distributions caused by the sharp distal dose gradient. This presentation will discuss two examples for the application of Monte Carlo dose calculation in proton therapy:

1. Monte Carlo for treatment dose verification

The modeling of the beam delivery system itself opens various areas where Monte Carlo calculations prove extremely helpful, such as for design and commissioning of a therapy facility as well as for quality assurance verification. Monte Carlo calculations can help to understand the sensitivity of beam characteristics and how these influence the dose delivered. With the capability of reading CT data information, Monte Carlo codes are able to model patient anatomy. A software link of the Monte Carlo dose engine to the patient database and the commercial planning system can thus be established to allow to use Monte Carlo re-calculated dose distributions as a benchmark for analytically generated treatment plans or even to do full Monte Carlo based treatment planning. Using a simulation of the ionization chamber reading in the treatment head allows the Monte Carlo dose to be specified as dose to tissue in absolute units. This presentation will review the implementation of a proton Monte Carlo dose calculation engine in the clinic and discuss a few results, i.e. comparisons between Monte Carlo generated and analytically generated dose distributions for protons.

2. Secondary neutron dose

There is a growing concern for the risk of developing cancer due to radiation treatments, in particular for pediatric patients. Protons deposit secondary dose outside the treatment volume predominantly via neutrons (generated either in the patient or the treatment head). Organ dosimetry is necessary for epidemiological studies of secondary cancer risk, especially for body regions not imaged for treatment planning. However, organ equivalent doses and effective doses within human body are not directly measurable. One way of estimating organ dose distributions is through the use of computational anthropomorphic phantoms coupled with Monte Carlo algorithms. This presentation will demonstrate how Monte Carlo simulations are used to assess neutron doses on the example of age and gender specific whole-body phantoms. Some of the findings from a recent project aiming at assessing the dose from secondary radiation in patients undergoing proton treatment will be summarized. Neutron dose to the patient depends on several factors, for example the field size incident to the patient specific collimator and the patient's age. The estimation of cancer risk based on these data will be discussed.

Educational Objectives:

1. Understand the importance and challenges of Monte Carlo techniques in (proton) radiation therapy
2. Understand the use of whole-body computational phantoms for dose simulations and the risk associated with scattered neutron radiation