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The use of MonteCarlo computation tools in the Hadron Therapy Facility MedAustron

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MedAustron is an accelerator facility with a synchrotron for cancer therapy and research located in Wiener Neustadt, 50 km south of Vienna. The facility provides protons up to kinetic energies of 250 MeV and carbon ions up to 400 MeV/u for medical applications. Additionally, protons up to 800 MeV kinetic energy can be used for non-clinical research purposes in a dedicated room.
The concept of the MedAustron particle accelerator was developed in cooperation with the European Organization for Nuclear Research CERN. The system is comprised of active beam scanning on fixed beam lines, as well as a proton gantry.
Since 2016, the MedAustron Particle Therapy Accelerator MAPTA is a CE-labeled medical product in accordance with the European medical device directive. In the same year, treatment of tumor patients, as well as research with protons, commenced, with more than 2300 patients having completed their treatment so far. Commissioning of helium beams has now also started –the associated operating permit is expected to be granted in 2024.
The use of Monte Carlo computational tools have played a crucial part since the beginning of the project, being used for various applications. The radiation protection group, for example, uses FLUKA to create detailed technical reports for complex authority approval procedures, such as the extension of the operating permit to accelerate stable ions between hydrogen and neon.
Just recently, a new Environmental Impact Assessment procedure was started for the extension of the facility with a commercially available cyclotron including a gantry system providing protons up to 230 MeV for patient treatment in a 5th irradiation room. This involved FLUKA simulations to ensure sufficient shielding and estimate activation of components and building parts, including a comparison to MCNP simulations of similar facilities performed by the vendor.
At the interface between Radiation Protection and Medical Physics, an ongoing project explores the use of voxel geometries of actual patients for a detailed assessment of clinical doses in cases where the transport of secondary particles (beyond standard treatment planning systems) is necessary for exact dose predictions (e.g. close to implants).
Additionally, smaller questions arising in daily operation are resolved with the help of the Monte Carlo Code FLUKA: optimization of bite splints for sinus irradiation, assessment of water activation in the water phantom using carbon ions, comparison of measurement and simulation of ambient dose rate in the room during patient treatment, etc.
The Accelerator Beam Physics group also uses FLUKA for the assessment of beam scattering in the dose delivery system by sampling measured beam profiles as source terms. Specific failure scenarios were assessed and collimators were designed to limit beam outside the intended beam scanning field, in order to achieve certification as a medical device in accordance with IEC 60601-2-64.
The Medical Physics Department has harnessed GATE/Geant4 across various domains, encompassing dose delivery monitor gain calibration, ocular beamline design, validation of the particle energy spectra look up tables in the TPS, or ripple filter development. An ongoing initiative seeks to replace patient-specific quality assurance measurements, typically conducted per field of each patient plan, with in-silico simulations employing GATE/Geant4. To ensure compliance with legal regulations, an Application Programming Interface (API) was developed for seamless integration with the commercial software platform myQA iON by IBA Dosimetry, which currently only supports proton beams via the MC engine MCSquare. This endeavor targets the

optimization of beamtime allocation and enhancement of dose verification specificity, promising significant advancements in clinical practice.

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