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Towards GATE 10 for ion beam therapy applications

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In ion beam therapy, Monte Carlo (MC) particle transport simulations are being increasingly used to perform independent dose calculation (IDC) for quality assurance in light ion beam therapy. In practice, IDC consists in recomputing the dose in the patient starting from the treatment plan specifications, with a Monte-Carlo engine. The results can be compared with the planned dose as a verification of the treatment before delivery to the patient.

As a carbon ion treatment plan (TP) consists typically in the order of several 104 single Pencil Beams (PBs), small errors in the description of a single PB may add up to a considerable discrepancy in the treatment plan. Therefore, first we implemented the PB source into GATE 10. A single PB is characterized with 3 parameters to describe the particle type, mean energy and energy spread and 8 parameters to describe the (correlated) beam optics (spot size, divergence, emittance, convergence flag; each for the x and y direction). The implementation on the C++ side follows what was already existing in GATE 9, however substituting the external CLHEP library to sample from a correlated bivariate Gaussian distribution with a custom implementation. The implementation was verified on 5 test cases agreeing within tolerances with GATE v9.3 and GATE-RTion v1.
In a second step a beamline model class was introduced. As in the previous version, the energy dependent parameters of a specific beamline can be described with a polynomial function of n-th order.

In the third step, the TP source was implemented initiating several PB sources using the parameters calculated from the beamline model. Test cases created to verify absolute dose, optics and rotations of the TP source simulations, are in good agreement with GATE-RTion v1.

The PB source, ion source description (beam model) and TP source were successfully translated from Gate 9 to Gate 10 making use of the new python interface and new features were added and verified.

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