Development and experimental validation of TPS software to determine the dose outside the radiation beam
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Development and experimental validation of treatment planning system software to determine the whole-body dose in radiotherapy

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MOTIVATION
• In the fight against cancers, radiotherapy remains the most powerful and widespread technique.
• Risk of generating second cancers and heart diseases after a first treatment due to x-rays leakages and scattered radiations that depose out-of-field dose1.
• At the moment, TPS optimize the effectiveness of radiation therapy, based on dose distributions in the target volume, but the dose distributions to distant organs are not provided.
• It could help the therapist to know the peripheral dose before the treatment in order to predict and reduce the iatrogenic effects.

Our solution: develop a Monte Carlo tool giving the whole-body dose in a reasonable time. The peripheral dose is low and consequently difficult to simulate with a small statistical uncertainty.

MATERIAL and METHODS
Code:
• Tool based on the Penelope2 Monte Carlo particle transport code, high accuracy on the dose deposition.
• Calculation of the dose at any part of the patient’s body while carrying out treatment planning.
• Implementation of variance reduction techniques to improve the efficiency: better uncertainty for the same simulation time.

Experimental validation:
On the GE Saturne 43 conventional linac on a specific large water tank at 6, 12 and 20 MV with a 10 × 10 cm² field at the French Primary Standard Laboratory (done) and an IMRT accelerator on an anthropomorphic phantom (autumn 2011). Use of the OSL (Optically Stimulated Luminescence) dosimeters: Nanodot from LCIE Landauer.

RESULTS
Measurements and calculations on the Saturne 43:
Considering that the ionization chamber dose is the reference value, OSL over-estimate the dose at large distance from the beam centre. It is due to the energy dependence of the dosimeter’s response to low energies.

The Penelope code fits better (mean error 3 %) with the reference than the MCNPX code (mean error 30 %). But Penelope is too slow and time consuming for a clinical application (26 hours on 108 processors to calculate the dose in the water tank).

Consequently, we need to accelerate the calculation by implementing the Dxtran variance reduction technique.

OSL energy dependence correction:
High over-response below 100 keV. Importance of low energy photons far from the field (Penelope calculations).

After correcting the energy dependence, the OSL dosimeters will give satisfying results so that they could be used to validate the code in a real IMRT configuration.

OUTLOOK
• Implementation of the pseudo deterministic transport variance reduction technique in Penelope (in progress).
  Subdivision of particle at each interaction: one is forced to reach a region of interest (virtual particle), the other one is the real one that follow its history (non deterministic transport).

• Measurements and validation on an anthropomorphic phantom with OSL detectors.

REFERENCES