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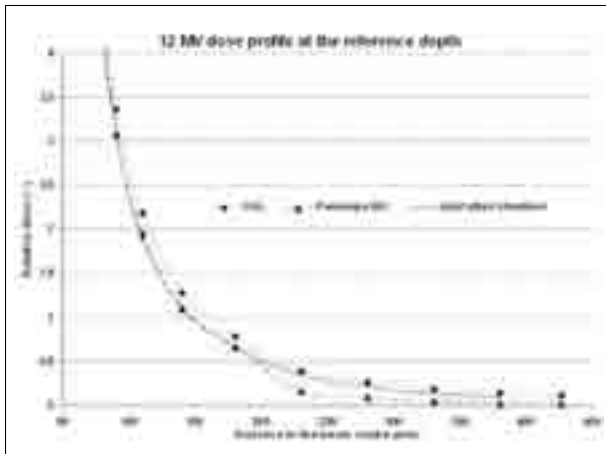
DEVELOPMENT AND EXPERIMENTAL VALIDATION OF TPS SOFTWARE TO DETERMINE THE DOSE OUTSIDE THE RADIATION BEAM

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Purpose: Even if the IMRT modality allows a more accurate definition of the target volume in radiotherapy, low doses are still delivered around the tumour to organs at risk. Epidemiological studies demonstrated the relationship between peripheral doses and second cancers or heart diseases. Our aim is to develop a Monte Carlo tool to compute the dose at the target volume and the organs at risk in order to enable a decrease of the peripheral dose by adapting the treatment's parameters. This tool will be implemented in a TPS (Treatment Planning System). In this paper we expose the first validation step of the out-of-field Monte Carlo calculations, using a comparison with measurements in a specific water tank.

Materials: The PENelope MC (Monte Carlo) code has been parallelized to save computation time by running the calculations on a cluster of 84 processors. To validate the simulations results, OSL (Optically Stimulated Luminescence) dosimeters made of Al₂O₃:C were used. The OSL Nanodots are manufactured by LCIE Landauer. The OSL measurements are compared with NE2571 IC (ionization chamber) measurements. Irradiation has been done at LNHB (French Primary Standard Laboratory) on a GE Saturne 43 accelerator at the 6, 12 and 20 MV qualities. The only difference with the irradiation conditions proposed in the AIEA protocol 398 is the use of a large water phantom specially machined for this experiment; it is a 60x30x30 cm³ tank.

Results: Three main corrections are done on the OSL measurements: particular sensitivity for each Nanodot, air calibration factor D_{water}/K_{air} and energy dependence correction. The picture shows out-of-field dose profiles at reference depth (10 cm) for MC calculations, ionization chamber and OSL measurements. The doses are normalized to the maximum of dose. In this figure, the energy dependence is not corrected for the OSL. Considering that the ionization chamber dose is the reference value, one can observe that OSLs always over-estimate the dose. The energy response of the OSL dosimeter has been investigated to correct this over response.



The MC data are in good agreement with the IC measurements up to 200 mm from the centre of the beam. For further positions, the calculations underestimate the dose in comparison with the IC measurements. In the beam, the data are in good agreement (error < 3 %).

Conclusions: After correcting the energy dependence, the OSL dosimeter will give satisfying results so that it can be used to validate the calculations of the new MC calculation tool in a real IMRT configuration with an anthropomorphic phantom. Further research is necessary to explain the discrepancy between measured and calculated dose for large distances. Besides, the implementation of reduction variance techniques in the MC tool should be helpful by allowing a better accuracy of the calculation out of the beam. Part of the work has been done within the frame work of EURADOS WG9.

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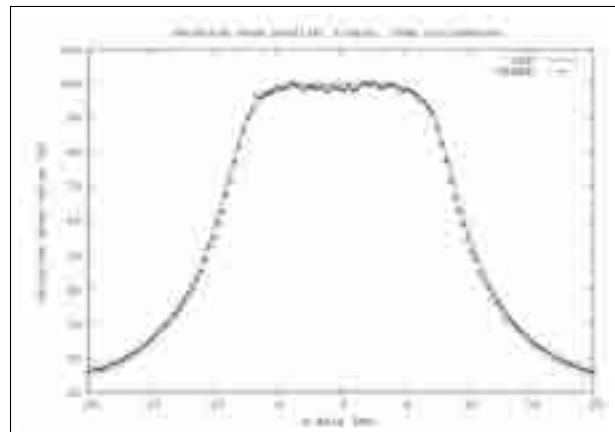
FLUKA MONTE CARLO SIMULATION FOR THE LEKSELL GAMMA KNIFE PERFEXION: HOMOGENEOUS MEDIA.

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Purpose: The purpose of this work is to investigate the capability of the FLUKA Monte Carlo (MC) code to reproduce the predictions of the Elekta Leksell Gamma Knife Perfexion (LGK-PFX) treatment planning software Leksell GammaPlan (LGP) for an homogeneous target. This is the first step to build a MC verification of treatment planning in actual clinical cases.

Materials: The LGK-PFX is a ⁶⁰Co medical device based, manufactured by Elekta AB Sweden, able to apply a sophisticated radiation surgery technique for the treatment of different brain pathologies. By means of three different collimator sets (4, 8 and 16 mm) gamma rays are focused on the isocenter of the field. LGP is the treatment planning software specifically designed for LGK-PFX. Since LGP employs a simplified physical model, the quality assurance program requires to verify its the output by means of external methodologies. The intrinsic difficulties of dose measurements, especially in small beams field, makes the Monte Carlo (MC) method a suitable and powerful tool in order to perform an accurate dosimetric comparison in critical regions. FLUKA is a multipurpose MC code which finds many different applications in physics, developed as a joint project of INFN and CERN. It computes transport and interaction of particles over a wide energy range. Thanks to the collaboration with Elekta, which provided us with the technical construction details of the Perfexion radiation unit under a confidential agreement, we could build an accurate input model for our FLUKA simulation. In order to validate the MC results, we have compared to LGP results the relative linear dose distributions along the three coordinated axes for each kind of collimator size and the output-factor (OF) for various size of scoring volumes. A satisfactory agreement has been achieved between FLUKA calculations and the LGP predictions.

Results: FLUKA MC calculation provided the OF values of 0.921 and 0.792 for the 8mm and the 4mm collimators. These values are in good agreement with the Elekta provided data which are 0.924 and 0.805 respectively. As a first example of the good agreement achieved in the relative linear dose profile comparison, the 16mm collimator profile along the coordinated x-axis is shown in figure.



Conclusions: The results obtained in this work show that our full FLUKA simulation is able to reproduce the LGP prediction in homogeneous media. We can now proceed to work at the comparison of MC results with LGP predictions in the case of heterogeneous targets.

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MONTE CARLO BASED ELECTRON BEAM TREATMENT PLANNING FOR BREAST CANCER

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Purpose: Breast cancer is the third most common type of cancer in Canada with nearly 23 300 new cases per year. Current treatment options include a combination of surgery, chemotherapy, hormonal therapy and radiation therapy (RT). For early stage invasive breast cancer, a breast-conserving treatment involving RT is usually the preferred treatment. It involves tangential photon fields to the whole breast followed by an electron boost field to the tumor bed. Electron RT, under a specific suitable geometry may offer a number of advantages over photon RT. The high surface dose, combined with a rapid dose fall-off beyond the target volume may increase the tumor control probability and may decrease the normal tissue complication (lung, heart). Deterministic algorithms for electron dose calculations that are found in commercial planning systems often yield treatment planning inaccuracies. Therefore electron treatments are mostly clinically planned without dose distributions. Our current research aims to use Monte Carlo (MC) methods, incorporated within the McGill Monte Carlo Treatment Planning (MMCTP) system, to model