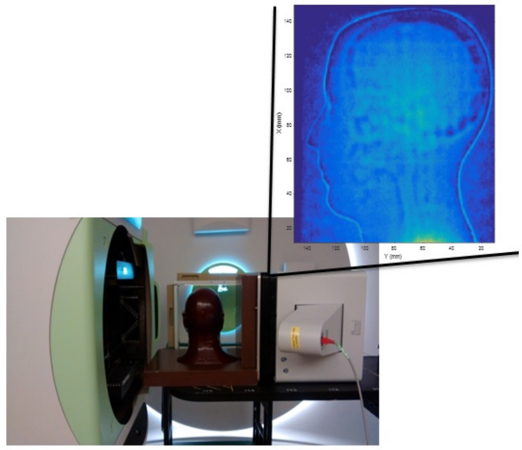

Figure 1. Experimental set-up with an example of proton radiograph imaged at beam energy of 220 MeV.

Results

In this study we demonstrate the robustness of the energy resolved dose measurement method for single detector proton imaging. It shows the capability to determine the WEPL with sub-millimeter accuracy in a homogeneous target and performs well in heterogeneous target, proving an accuracy better than 2 mm even in most heterogeneous areas of a head phantom. These performances are achieved by using an imaging field with as little as 5 energy layers with spacing up to 10 mm between the layers.

Although the optimization of the imaging dose was not a goal of this study, only ~21 mGy per cm^2 is sufficient to obtain the above accuracies. This dose can be further decreased by using a detector with higher sensitivity and by reducing the number of beam spots per layer of the imaging field.

Conclusion

Proton radiography with single detector using energy resolved dose measurement did show potential for clinical use. Further studies are needed to optimize the imaging dose and the clinical workflow.

PO-0803 CloudMC, a Cloud Computing application for fast Monte Carlo treatment verification

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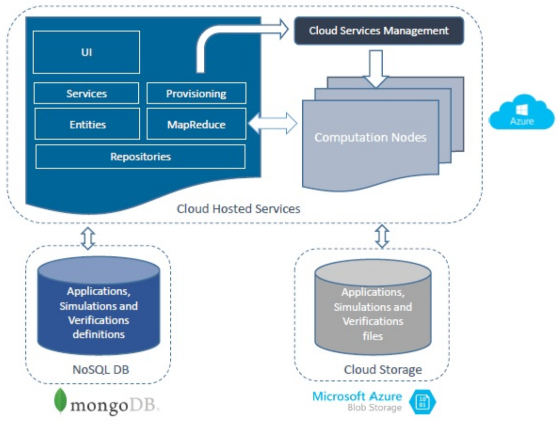
Purpose or Objective

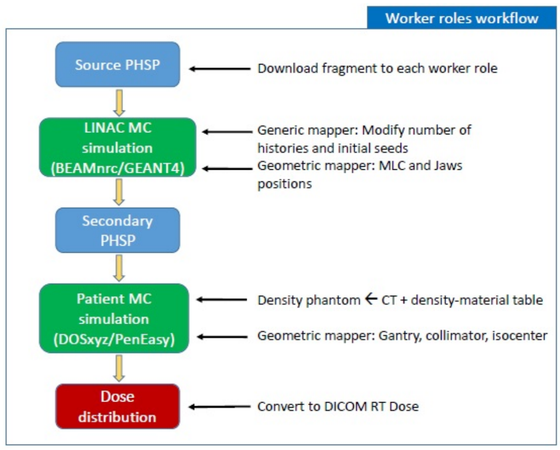
CloudMC is a cloud-based solution developed for r educing time of Monte Carlo (MC) simulation s through parallelization in multiple virtual computing nodes in the Microsoft's cloud. This work presents an update for performing MC calculation of complete RT treatments in an easy, fast and cheap way.

Material and Methods

The application CloudMC, presented in previous works, has been updated with a solution for automatically perform MC treatment verification. CloudMC architecture (figure 1) is divided into two units. The processing unit consists of a web role that hosts the user interface and is responsible of provisioning the computing worker roles pool, where the tasks are distributed and executed, and a reducer worker role that merges the outputs. The storage unit contains the user files, a data base with the users and simulations metadata and a system of message queues to maintain asynchronous communication between the front-end and the back-end of the application.



CloudMC is presented as a web application. Through the user interface it is possible to create/edit/configure a LINAC model, consisting of a set of files/programs for the LINAC simulation and the parametrization of the input and output simulation files for the map/reduce tasks. Then, to perform a MC verification of a RT treatment, the only input needed is the set of CT images, the RT plan and the corresponding dose distribution obtained from the TPS. CloudMC implements a set of classes based on the standard DICOM format that read the information contained in these files, create the density phantom from the CT images and modify the input files of the MC programs with the corresponding geometric configuration of each beam/control point.



A LINAC model has been created in CloudMC for the two LINACs existing in our institution. For the PRIMUS model BEAMnrc is used to generate a secondary phase space, which is read by DOSxyz to obtain the dose distribution in the patient density phantom. For the ONCOR model, a specific GEANT4 program and PenEasy have been used instead. In figure 2 the workflow in each worker role is described.

Results

IMRT step&shoot treatments from our institution are selected for the MC treatment verification with CloudMC. They are launched with $2{\cdot}10^9$ histories, which produce an uncertainty < 1.5% in a 2x2x5 mm^3 phantom, in 200 medium-size worker roles (RAM 3.5GB, 2 cores). The total computing time is 30-40 min (equivalent to 100 h in a single CPU) and the associated cost is about 10 €.

Conclusion

Cloud Computing technology can be used to overcome the major drawbacks associated to the use of MC algorithms for RT calculations. Just through an internet connection it is possible to access an almost limitless computation

power without the need of installing/maintaining any hardware nor software.
CloudMC has been proved to be a feasibly solution for performing MC verifications of RT treatments and it is a first step towards achieving the ultimate goal of planning a full-MC treatment a reality for everyone.

PO-0804 Relative dosimetry evaluation for small multileaf collimator fields on a TrueBeam linear accelerator

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Purpose or Objective
The aim of our study was to compare the performance of the PTW microdiamond detector 60019 and the E Diode 60017 in homogeneous media to MC calculations for small MLC fields. Two dosimetric algorithms: Acuros XB (AXB) and Analytical Anisotropic Algorithm (AAA) were also evaluated for these cases.
Material and Methods
The True Beam linear accelerator STx equipped with a HD120 MLC was accurately modelled with Geant4 application for emission tomography (GATE) platform using the confidential data package provided by Varian[1]. Its corresponding validation was carried out using measurement of depth dose profile (PDD), lateral dose profiles and output factors for 6FF and 6FFF static fields ranging from 5x5cm^2 to 20x20cm^2. Small MLC fields ranging from 0.5x0.5 cm^2 to 3x3 cm^2 were used for this part of study. The jaws were positioned at 3x3 cm^2 for MLC fields less than 2x2 cm^2 and 5x5 cm^2 for the rest. Measurements, corresponding to these configurations, were performed in a water phantom at a source surface distance of 95 cm using microdiamond and E diode detectors. The dosimetric accuracy of the detectors and the dosimetric algorithms were compared against MC calculations that were considered as a benchmark.
Results
Profiles measurements and calculations gave similar penumbras for both detectors and algorithms considering a source spot size of 0 for AAA and 1mm for AXB. Even though microdiamond detector should be less adapted for profile measurements due to the volume averaging effect that is more important than the E diode considering its geometry. Significant differences were observed between measured and calculated PDD for field size under 2x2 cm^2. The differences in the build-up region between MC and microdiamond detector for the MLC 0.5x0.5 cm^2 field were up to 5.8% and up to 5.6% at 15.5 cm depth. For the MLC 1x1 cm^2 field, smaller differences of 4.3% and 3.6% were observed in the build-up region and at 20.5 cm depth, respectively. The deviations between E diode and MC in the build-up region were up to 4.9% and up to 9.7% at 25 cm depth for a 0.5x0.5 cm^2 field size. Lower deviations of 3.5% and 4.7% were found for the 1x1 cm^2 field size in the build up region and at 20 cm depth, respectively. As for AXB and AAA algorithms, for the 0.5x0.5 cm^2 field size, differences were up to 1.8% and 2% in the build-up region, respectively. For higher depth differences were up to 3.8% and 3.7% for AXB and AAA calculations, respectively.
Conclusion
Our study showed that the microdiamond is less sensitive to dose rate dependence and is more accurate than E Diode for PDD measurements. Correction factors should necessarily be applied for both detectors and calculation algorithms in homogenous medium for fields under 2x2 cm^2. Further studies on the output factor correction factors are ongoing.

1. Constantin M, Perl J, Losasso T, et al. Modeling the TrueBeam linac using a CAD to Geant4 geometry implementation : Dose and IAEA-compliant phase space calculations. 2011;38(July):4018-4024. doi:10.1118/1.3598439.

PO-0805 Commissioning of the new Monte Carlo algorithm SciMoCa for a VersaHD LINAC

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Purpose or Objective
To validate the dose calculation accuracy of the Monte Carlo algorithm SciMoCa (ScientificRT GmbH, Munich, Germany) for a VersaHD (Elekta AB, Stockholm, Sweden) linear accelerator. SciMoCa is a recently developed Server/Client based Monte Carlo algorithm, which provides fast and accurate dose calculation for various applications, e.g. independent dose assessment of 3D-CRT, IMRT and VMAT treatment plans or general research purposes.
Material and Methods
A beam model of a 6 MV flattened beam provided by a VersaHD was used to calculate the dose distribution of square fields in a virtual 40 x 40 x 40 cm^3 water block. The investigated field sizes ranged from 1 x 1 cm^2 to 40 x 40 cm^2. For the acquisition of percentage depth dose profiles (PDDs) and for output factor measurements, a PTW Semiflex 31010 was used for field sizes down to 3 x 3 cm^2 and a PTW DiodeE as well as a PTW microDiamond were used for field sizes ranging from 1 x 1 cm^2 to 10 x 10 cm^2. The measured output factors were corrected for small field effects where necessary. The lateral profiles of all fields were acquired using a PTW DiodeP at depths of dmax, 5 cm, 10 cm, 20 cm and 30 cm, respectively. A calculation grid size of 2 mm and a Monte Carlo variance of 0.5% were used for the calculations. PDDs and lateral profiles were extracted from the calculated dose cube. These calculated dose profiles were re-sampled to a grid size of 1 mm and compared to previously measured depth dose and lateral profiles using gamma index analysis with a 1 mm/1% acceptance criteria. The mean values of γ indices (γmean) as well as the relative difference of measured output factors (OF meas) and calculated output factors (OF calc) were used for the evaluation of the calculation accuracy.
Results
Table 1 summarizes the results of the gamma analysis of each investigated field as mean and standard deviation for each field. The mean values of γmean and the standard deviation of the mean increased with increasing field size. Figure 1 depicts the distribution of γmean values with respect to profile type, field size and measurement depth. The majority of γmean values were well below 1. The highest γmean values were found for the 40 x 40 cm^2 field and for larger measurement depths. The high γmean of the 40 x 40 cm^2 field were attributed to the size of the digital water phantom. The γmean values of the all PDDs were below 0.5 for all field sizes. The calculated and measured output factors agreed within 1% for field sizes larger and 1 x 1 cm^2. For the 1 x 1 cm^2 the difference between measured and calculated output factors was 1.5%.