End to end simulation of definitive calibration process in VERT.

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Introduction

The VERT system is used by a variety of training and clinical institutions across the planet. These facilities range from teaching institutions with large class groups to smaller clinical groups and community colleges. The majority these deliver Radiographer/ Therapist/ RTT programmes and indeed these were those originally intended to benefit from bringing the Linac into the classroom. In recent years we have been interested to open up the attraction and relevance to other Radiotherapy professionals and upgrade of the Physics modules was introduced with this in mind.

A key feature in VERT is the ability to simulate errors, mis-calibrations of the Linac and in general to learn, safely and without risk, from the experience of having made a mistake. These could be simple patient random set-up errors to systematic mis-calibrations of the Linac which, in reality would impact many patients until resolved.

In this article we briefly explore and discuss the simulation of the process behind calibrating an ion chamber such that it may be used to measure dose definitively for MV x-ray and MeV Electron beams.

Codes covered

The implementation of this process was based around the IAEA TRS398 dosimetry protocol. Though previously a simpler implementation of the IPSM 1990 X-ray code of practice had been

implemented, the current implementation was designed to be significantly more sophisticated and covers both MV X-rays and MeV Electron dosimetry. Furthermore, it has been used as a basis for similar modules simulating the TG-51 and IPEM 2020 protocols.

Linac calibration

Depending on the local codes of practice and historical practice, Linacs maybe calibrated under different conditions. In VERT the default configuration reflects the typical UK practice (1Gy/100MU for a 10cm x 10cm field, at 5cm depth, isocentrically), however this condition is definable by the user in the VERT system and any choice of condition can be used.

The Simulation

The Dosimetry simulation module in VERT requires the user to make the measurements needed to calculate, or look up, the correction factors to the Chamber's calibration factor which is either measured in a National Primary Lab or has been derived from similar and typically relates to a reference energy such as ^{60}Co.

The user makes point measurements or obtain depth dose plots as appropriate. Point charge readings obtained for the measurements are sensitive to condition (depth, field size, TSD) of measurement, user definable (with default settings) detector characteristics and measurement uncertainties whose magnitude are, again, user definable.

This base principal applies to the measurements required to calculate the Quality Indices that characterise the beam energy, the polarity correction factor or ion recombination factor. Whereas the details of computation or 'look-up' of each are protocol specific, they rely on accurate measurements being obtained.

If a measurement is made incorrectly at any step of the process, for example at a wrong depth or with a wrong field size, then the charge reading (or depth dose profile) will reflect the error and they persist through the exercise.

At all stages, a 'notepad' record of the measurement conditions, charge measurements made, factors created can be recorded and these may be 'cut/paste' into a document to create a report to record the experience or submit as part of as assessment.

Discussion

The simulation has been designed to allow the educators to show students how to work through the dosimetry protocols represented in VERT. The students will then practice the process and are able to virtually experience some of the pitfalls via the sophisticated and detailed implementation.

Procedural errors will ultimately result in an incorrect (lumped) calibration factor being produced. We are currently working on an extension to this that may allow us to quantify uncertainties in each step and demonstrate their combination into the final factor.

Ultimately, the student can use the calibration factor to recover the output of the Linac under its calibration conditions. If successful, they will quickly see (within random measurement uncertainties) that they have been successful or be able to work back through where they have made errors.

Conclusion

As with many of the available exercises in VERT, it gives the trainer and the user the chance to have detailed and comprehensive discussions and simulated practical experience with the relevant issues in the ‘classroom’ at convenient times in the day, without having to wait for a Linac to become free and then having to work into the evenings!