A method for in-vivo dosimetry using an electronic portal imaging device

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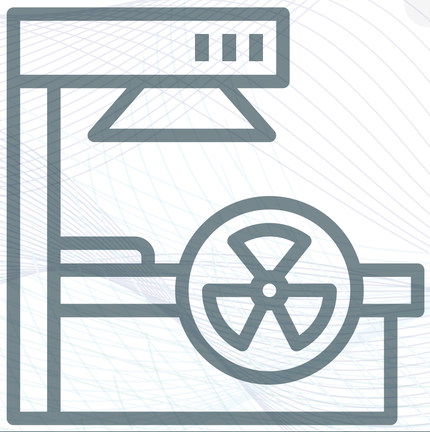
Radiotherapy



Risks:

- Set-up error
- Poor beam quality
- Dose delivered is lower (or higher) than prescribed
- Secondary malignancies

There is a need for reliable and effective treatment verification method

In-vivo dosimetry

A dose verfirication method conducted during the treatment; can be used to verify the actual dose delivered to the patient to assess accuracy of treatment delivery.

Conventional
Using an array of ionization chamber

Unconventional
Using an EPID (Electronic portal imaging device)

Advantages:

- Readily available in radiotherapy centers
- Produces digital image - can be easily retreived and processed
- 2D output - more information compared to point detectors
- Does not require additional treatment time and effort to set-up

Objective of the study

To develop an in-vivo dosimetry method using an Electronic Portal Imaging Device (EPID) via a mathematical model.

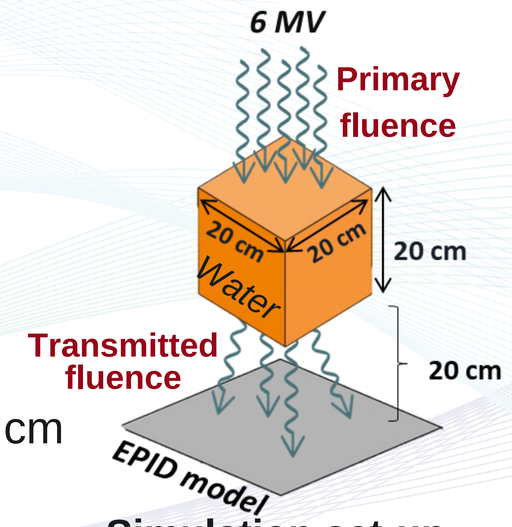
Materials and methods

Monte Carlo simulations using Geant4 Application for Tomographic Emmission (GATE) version 9.0.

Physics list: EMStandard_opt3

Number of events: 1 million

EPID detection area: 40 cm × 40 cm



Simulation set-up

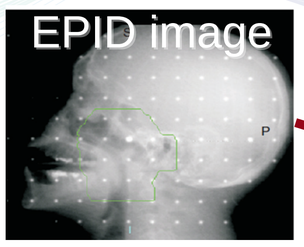


Diagram of target dose calculation using the transmitted fluence detected at the EPID level

Fluence value detected by the EPID

Conversion of EPID pixel value to primary fluence value

back-projection

$$\Phi_{photons(t-x)} = \Phi_{photons(EPID)}\, e^{\mu t}$$

Fluence value inside the target

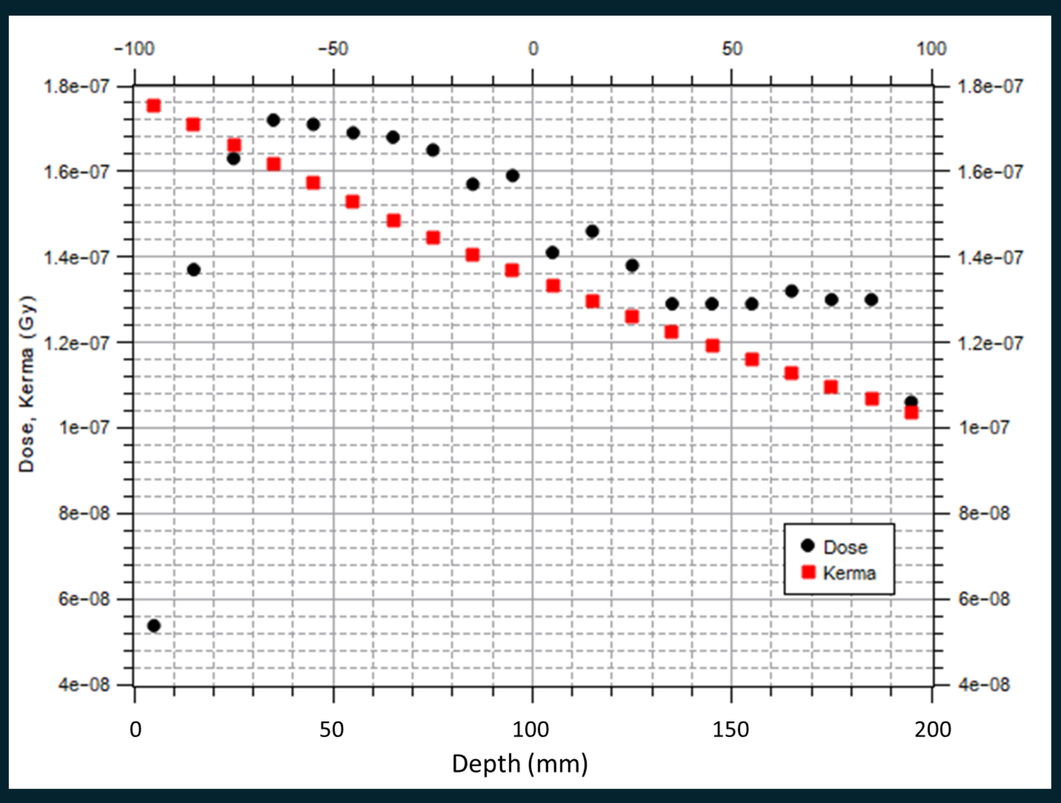
Collision kerma

$$K_{col} = h\nu\, \Phi_{photons(t-x)} \left(\frac{\mu_{en}}{\rho}\right)$$

Absolute dose value

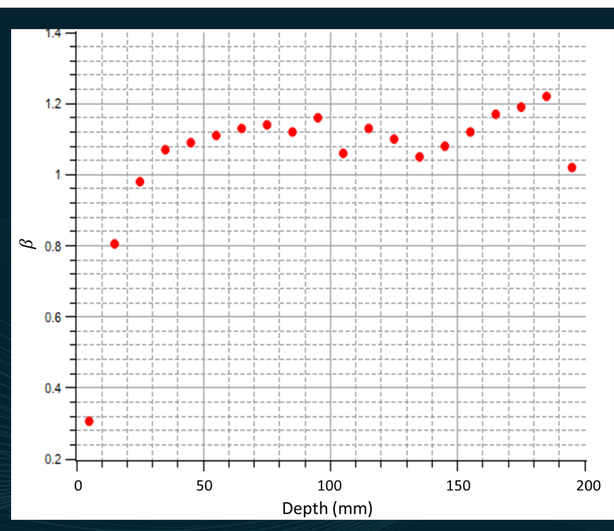
$$D_{photons} = \beta\, K_{col}$$

Results and discussion



Dose and the calculated collision kerma along the beam's central axis

The difference between the collision kerma and absorbed dose originated to the difference in the amount and energy of incoming and outgoing charged particles hence the values of β also depend in these factors.



Values of β as a function of depth.

Conclusion

The porposed mathematical model shows promising potential for the calculation of the target dose by utilizing the information obtained from the transmitted fluence at the level of the EPID. If the values of the proportionality constant β will be available and standardized, calculation of dose inside the target during the treatment will be possible and it will be easier to assess accuracy of treatment delivery.

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