# Proposition of an in-vivo dosimetry system based on Cherenkov light measurement in radiotherapy treatments

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The interaction of a high-energy radiotherapy photon beam (6 MV) with a typical human tissue can enable the occurrence of the phenomenon known as Cherenkov light emission [1]. The capture of these emissions can be done simultaneously with irradiation of the treatment beam from CMOS imaging devices. The emitted and recorded Cherenkov signal will be proportional to the deposited dose. In this way, it is possible to extract instantaneous in-vivo dosimetric information that evaluates the correspondence between the superficially measured dose and the ideal dose expected by the planning systems [2]. At the same time, the capture of Cherenkov emissions can provide accurate information on the surface dose distribution in a given area in the beam incidence region, detailing any alterations that impair the distribution of doses in depth. This work established criteria for the most appropriate positioning of CMOS cameras to capture the Cherenkov spectrum, which must be installed in a Radiotherapy Bunker to enable a technological solution for instantaneous in-vivo measurement of the dose deposited on the surface of a patient under treatment. Several hypotheses were tested for luminosity, absorption and scattering correction. The capture device installation project took into account all the typical parameters of radiotherapy equipment that directly or indirectly influence the position of the patient undergoing treatment. In parallel, the best geometric conditions of the Setup to capture scattered photons via Mie and Rayleigh scattering were studied and explored. In order to test the proposed hypotheses, an additional experimental study was carried out to determine the exposure received by the cameras that were eventually not foreseen in the simulations. The results of this work proposed 3 eligible configurations for the installation of Cherenkov capture devices. Some positions initially listed as options empirically recorded significant exposure from leakage radiation from the linear accelerator head. Noise minimization and light signal optimization were proposed based on the use of filters and signal amplifiers. The next stage of the work will be to test the positions presented in treatments performed in water simulators.

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[2] Jarvis, L. A., Zhang, R., Gladstone, D. J., Jiang, S., Hitchcock, W., Friedman, O. D., Glaser, A. K., Jermyn, M., & Pogue, B. W. (2014). Cherenkov Video Imaging Allows for the First Visualization of Radiation Therapy in Real Time. International Journal of Radiation Oncology*Biology*Physics, 89(3), 615–622. https://doi.org/10.1016/j.ijrobp.2014.01.046

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# Study on the radiation exposure of Portable X-ray Fluorescence

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### Introduction

Portable X-ray Fluorescence (pXRF) analysis is an analytical technique that allows for the almost instant determination of the chemical composition of a wide range of samples. The technique is non-destructive, and the equipment is lightweight and easily portable, making it highly useful in various situations. Recent studies suggest that the application of pXRF for multi-elemental analysis in blood samples shows very promise for clinical practice. Despite the low levels of radiation emitted by these devices, caution must be taken in their handling. The objective of this study is to conduct a radiometric survey of an experimental setup for pXRF analysis of blood samples.

### Methods

The X-ray Fluorescence analysis was performed using a compact X-ray spectrometer model X-123 SDD with Ag target. The experimental setup consisted of an compact X-ray spectrometer (Amptek) with Ag target, a semiconductor detector X-123SDD, and an acrylic stand, where Whatman N.42 paper were inserted. Measurements were performed using a calibrated Radcal® ionization chamber, model 10x5, the 1800 $cm^3$ volume, which has application for radiation protection.

The measurements were performed under two conditions: for the maximum current and voltage values of the equipment, and for the current and voltage values of the blood sample analysis protocol. Measurements were performed with the ionization chamber at various distances, 21, 35, 100 and 200 cm, and varying positioning in relation to the source.

### Results

With the direct X-ray beam in the ionization chamber, at a distance of 200 cm from the source, a maximum kerma rate of $3.27 \times 10^{-8}$ Gy/s was obtained. With the ionization chamber positioned 21 cm to the side of the detector, the maximum kerma rate was $5.25 \times 10^{-11}$ Gy/s. The maximum kerma rate with the ionization chamber positioned 35 cm behind the source was $9.27 \times 10^{-12}$ Gy/s, a value very close to the background.

### Conclusions

Preliminary measurements showed that the equipment operator is safe when positioned behind, or even to the side of the pXRF. But further tests must be carried out for the reliability of the entire system.