Design and commissioning of a Silicon Photomultiplier based dosimeter for Low Dose Rate (LDR) oncological brachytherapy

Romualdo Santoro

On behalf of the ORIGIN consortium

Dipartimento di Scienza e Alta Tecnologia, Università degli Studi dell'Insubria, (Como, Italia)

**Contact E-mail: romualdo.santoro@uninsubria.it*

ABSTRACT

Brachytherapy is a radiotherapy procedure performed with radioactive sources implanted into the patient's body, close to the cancer-affected area. This is a reference procedure to treat prostate and gynaecological cancer thanks to the reduction of the released dose in the proximity of organ at risk (i.e., rectum, bladder, colon) [1]. For this reason, real-time dose verification and source localisation are of enormous importance for a successful treatment plan. The ORIGIN project [2], supported by the European Commission (Horizon 2020 framework program), decided to respond to this medical community's need by developing a multi-point dosimeter with source localization capability. The system implements 16 clear fibres, engineered to house in the tip a small volume of scintillating material (Gd_2O_2S:Tb) emitting at 544 nm with a decay time of about 500 μs. The light produced by the primary γ-ray, interacting with the scintillating tip, hits the detector with a sequence of single photons and, despite of the low dose used in the treatment (0.4-2 Gy/h), it returns to be a multiplication factor of the primary event allowing to improve the dose sensitivity provided that the system can detect single-photons [3].

Silicon Photomultipliers (SiPMs) are a natural choice for this application since they provide single-photon sensitivity, detection efficiency higher than 30% at the wavelength of interest and fast signals (few ns). Each of the 16 fibres is coupled to a dedicated SiPM and the measurement is performed by counting single photons in time windows of 0.1 s. Thermoelectric-cooled SiPMs have been selected to achieve the requested sensitivity at 30 mm and to operate the dosimeter in stable condition (constant DCR) but, since the package forces to increase the fibre-to-sensor distance, a careful design was required to optimize the light collection. In this respect, an optical coupling system made of a spheric lens plus a focuser and fibre collimator, allowed to improve the sensitivity by a factor 4 with respect to the room temperature operation.

By the time of the conference, we will be able to discuss the system commissioning and the performance in clinical environment with LDR sources.

1. M.W. Chao, et al. Brachytherapy: state-of-the-art radiotherapy in prostate cancer. *BJU Int* **2015**, 304 *116*, 81–88. https://doi.org/10.1111/bju.13252.
2. https://origin2020.eu
3. M. Martyn, et al. Water Phantom Characterisation of a Novel Optical Fibre Sensor for LDR Brachytherapy. IEEE Sensors Journal, Vo3. 23, NO. 2 (2023). DOI: 10.1109/JSEN.2022.3225007