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DESIGN OF ORGANIC SCINTILLATORS FOR NON-STANDARD RADIATION FIELD DOSIMETRY: EXPERIMENTAL SETUP

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Abstract— **This paper describes an experimental setup designed for sensing the luminescent light coming from an organic plastic scintillator stimulated with ionizing radiation. This device is intended to be a part of a complete dosimeter system for characterization of small radiation fields which is the project of the doctoral thesis of the medical physicist at the Radiation Oncology facility of Hospital San Vicente Fundación in conjunction with the Universidad de Antioquia of Medellín Colombia. Some preliminary results predict a good performance of the unit, but further studies must be conducted in order to have a completed evaluation of the system. This is the first step in the development of an accuracy tool for measurement of non-standard fields in the Radiotherapy or Radiosurgery processes.**

I. Introduction

The main goal of the present paper is to design a prototype for sensing the luminescent signal coming from a plastic organic scintillator coupled to an optical fiber for further processing. The luminescent signal is composed by the scintillator's response to radiation and the noise produced by the Cherenkov effect over the optical fiber. The experimental setup must allow the acquisition, filtering and quantification for both signals in order to link the luminescent signal produced by the scintillator as a response to the quantity of radiation received over it [1, 2].

Modern radiotherapy techniques modify in a drastic way the energy flow through the area to be radiated, transforming the macroscopic radiation field concept into a finite tiny fields set for which the dose planning system model has not been well established yet and at the same time for which the ionization chamber, that is used for calibrating purposes, has lost its accuracy [3, 4].

These calibration models and systems have shown good accuracy for measuring the radiation dose delivered when the radiation field sizes are higher than 3 cm. For field sizes smaller than this, the lateral equilibrium of charged particles start to be insufficient causing that charged particles set in motion in the measurement region of the ionization chamber are not laterally replaced by other charged particles in order to maintain the electronic equilibrium therefore the measurement performed by the chamber yields a lesser value than the real radiation dose [3].

An alternative for those calibration systems are the organic plastic scintillators of tiny dimensions. These devices present as the main advantage over other systems the fact of having a mass density, electronic density and molecular composition similar to water and human tissue. Their low energy, dose rate and temperature dependence among others, make them efficient devices to be studied and used as dosimeters when small fields dosimetry problems are dealt with, as it is usual in new technology for treating cancer with ionizing radiation [1, 2, 5]

II. Materials and Methods

The system designed is composed by three stages as it is shown in Fig. 1. The first stage includes an organic plastic scintillator (Saint-Gobain Crystals) with a 530 nm emission peak (green region) coupled to a plastic optical fiber (Eska™) that produces a blue luminescent light due to the Cherenkov effect [6].

Second stage consists of the sensing light system which includes the color sensing device MCSiAT/BT (MAZeT GmbH). This device is composed by a hexagonal matrix of 19x3 photodiodes optically conditioned by a spectral dielectric filter in the standard primary colors of CIE space color (Commission Internationale de l'Eclairage).[7]
This device delivers a proportional current to each color in the RGB space color. Then a MTI04, that is a programmable gain transimpedance amplifier (MAZeT GmbH) with multiple channels, is used for signal conditioning of the three current outputs of the color sensing device (Green, Red and Blue). There is one transimpedance amplifier per channel between a current input and a voltage output. Its transimpedance is selectable in 8 stages. This adjustment can be effected,

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simultaneously in all the channels, by sending a command to the microcontroller which handles the setting of three digital inputs of the MTI04 [8].

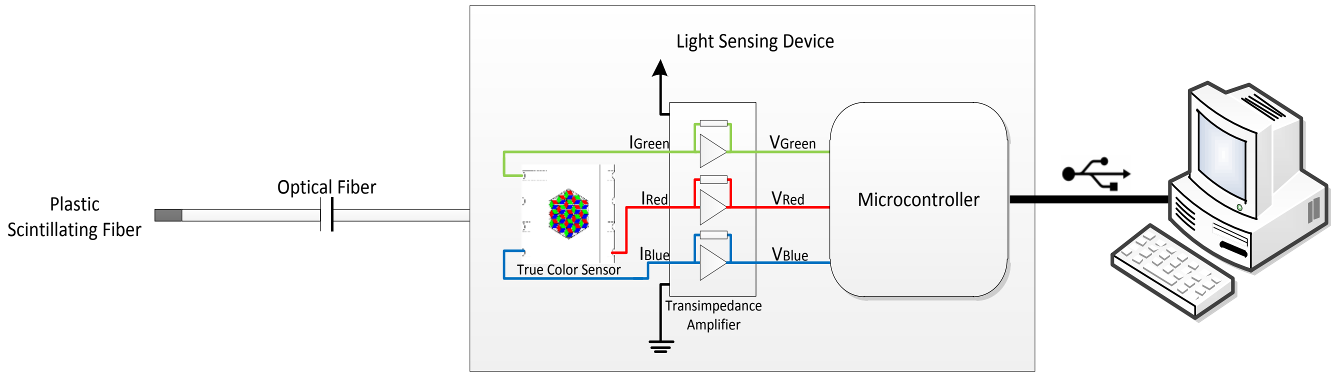

Figure 1. General Block Diagram of the Experimental Setup Prototype.

Table 1 shows the command send to the microcontroller, the settings of digital inputs and the transimpedance resistance.

TABLE 1. Adjustment of transimpedance.

Command	Settings of Digital Inputs			Transimpedance Resistance
	DI1	DI2	DI3	
st1	1	1	1	20MΩ
st2	0	1	1	10MΩ
st3	0	1	0	5MΩ
St4	1	0	1	2MΩ
st5	0	0	1	1MΩ
st6	1	0	0	500kΩ
st7	1	1	0	100kΩ
st8	0	0	0	25kΩ

The last element of the sensing light system is a control and processing component, which is based on a S08JM60 microcontroller (Freescale™ Semiconductor) and has three main tasks:

- Signal Acquisition: The three voltage outputs from the MTI04 are acquired by the microcontroller through the 12-bit analog-to-digital converter (ADC) interface.

- Communication with the Software: The Serial Communications Interface is used to the data exchange between the microcontroller and the software. Wherein the microcontroller sends the digital data obtained from the sensing light system, and receives the configuration parameters such as sampling frequency and Transimpedance commands. To connect the device with the computer using USB, The UART-USB bridge, FT232 (FTDI Chip Ltd.), has been used.

- Transimpedance Control: Three pins from the microcontroller where used as digital outputs, to control the adjustment of transimpedance, according to what were shown in the table 1.

Last stage consists of a Graphic User Interface (GUI) shown in Fig.2. This GUI allows a comfortable visualization of the information acquired by the sensing light device besides the manipulation of some parameters of the color transducer.

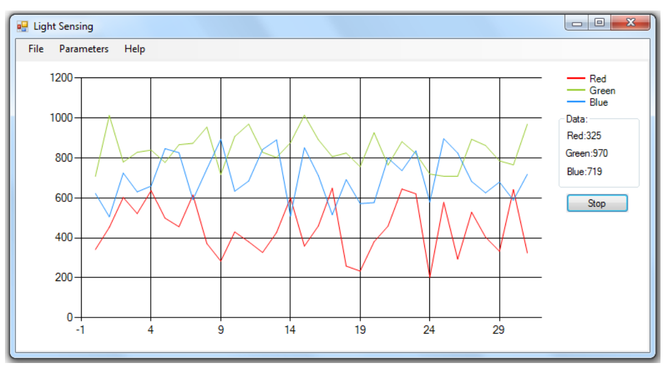

Figure 2. Graphic User Interface implemented.

I. RESULTS AND DISCUSSION

The Experimental setup designed is shown in Fig.3. The system was built using Superficial Mount Devices (SMD). Nevertheless, the first stage is finished and some preliminary results are obtained, a strict calibration process must be started prior to the developments of new studies in the characterization of non-standard radiation fields.

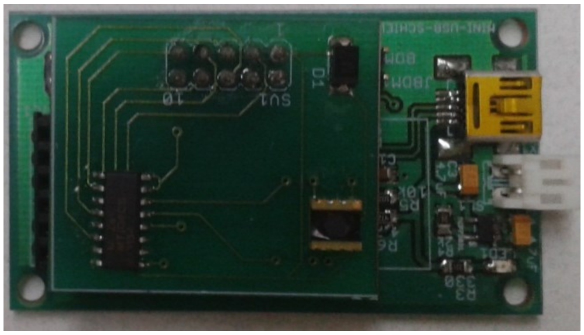

Figure 3. Experimental Setup implemented.

II. CONCLUSION

An Experimental Setup Prototype for sensing the luminescent light coming from an organic plastic scintillator stimulated with ionizing radiation was designed. This is the first stage in the development of a non-standard radiation field dosimeter for characterization of small radiation fields which will allow a better configuration of the planning systems in the radiation therapeutic process, warranting accuracy in the dose applied in the Modulated Intensity Radiotherapy and Radiosurgery processes. Nevertheless, further studies must be conducted in order to characterize and evaluate the system in clinical environments.

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