Dose-rate measurements based on commercial phototransistors using a modified reader unit

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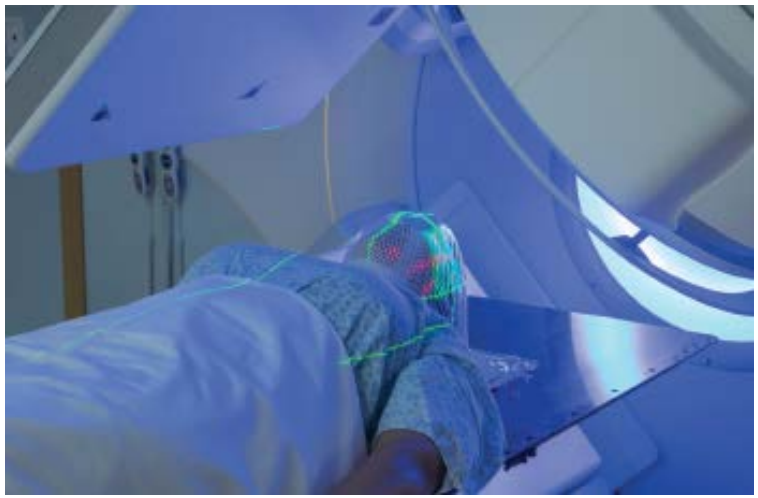
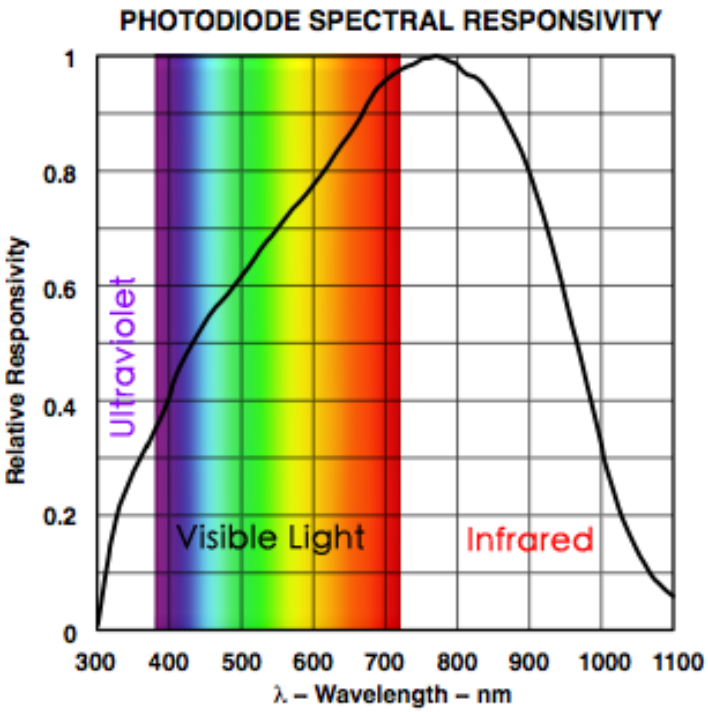
Introduction

- In vivo dosimetry is used in external beam radiotherapy (EBRT) [1] to detect major errors, to assess clinically relevant differences between planned and delivered dose, to record dose received by individual patients, and to fulfill legal requirements.
- Real-time detectors are capable of measuring the total dose during a treatment session



Introduction

- The main application of photodiodes and phototransistors is to measure visible, ultraviolet or infrared light.
- Some authors have reported their use as dose rate sensor for X-ray photon beams [2].



Reader unit

- Our research group previously developed a reader unit for MOSFET dosimeters [3].
- Our aim in this work was to extend the sensor interface capability of our reader. Therefore, a connectable module to measure dose rate from phototransistors is presented along with their response radiation.

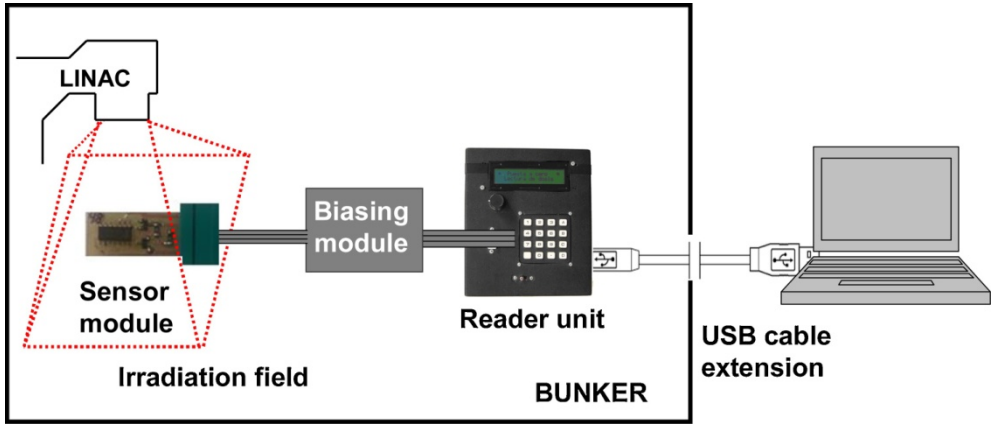


Figure 1. Diagram of the dosimetry system (sensor module, biasing module, reader unit, and PC) set up for the measurements.

Current voltage converter

- The main analog processing system is based on the operational amplifier TL072 (Texas Instruments, USA) with a feedback resistor of 4.7 MΩ.
- The output is low pass filtered and level shifted to our reader unit input.
- Data digitalized with the converter ADS8320 (Texas Instruments, USA), achieving a resolution of 0.2 nA.

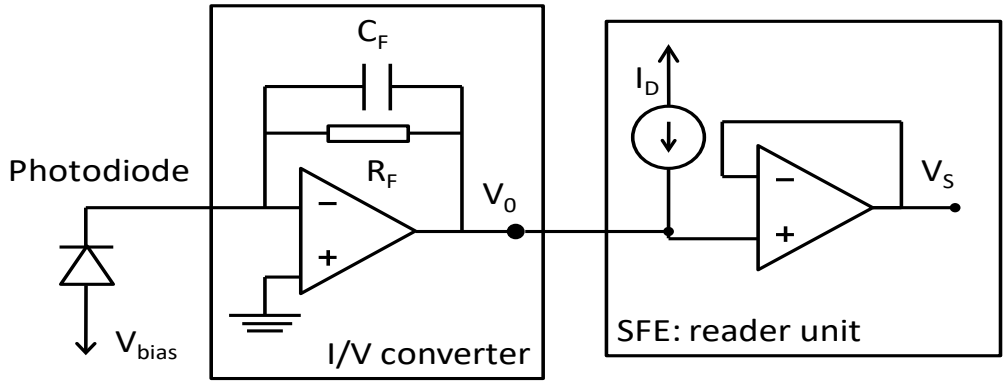


Figure 2. Schematic of I/V converter and Sensor Front End of the reader unit.

Irradiation unit

Two experiments were carried out with an irradiation field of 10x10 cm^2 in electronic equilibrium condition, and placing the devices at the isocentre of the radiation sources (at 100 cm) of the linear accelerators:

- Siemens Artiste, 6 MV: Devices to test BPW85B (Vishay Siliconix) and VTB8440BH (Excelitas Technologies).
- Siemens KDS, 18 MV: Device to test OP505 (Optek).

Figure 3. Linear accelerator Siemens Artiste (HUCSC).

Devices under test

Figure 4. BPW85B

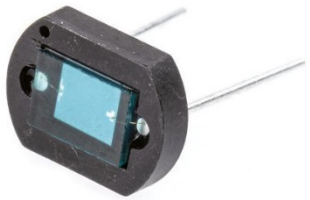


Figure 5. VTB8440BH

Figure 6. OP505

Experimental setup

- Dose rates from 0.5 to 3.0 Gy/min were applied to characterize the response of the reader module and the phototransistors.
- The reader unit was placed in the bunker and connected via USB cable with a computer.
- The response of the devices were monitored from high to low dose rate, and after, from low to high dose rates.
- To minimize the effect of ambient light, the devices were painted with nails polish and placed into a black plastic box.

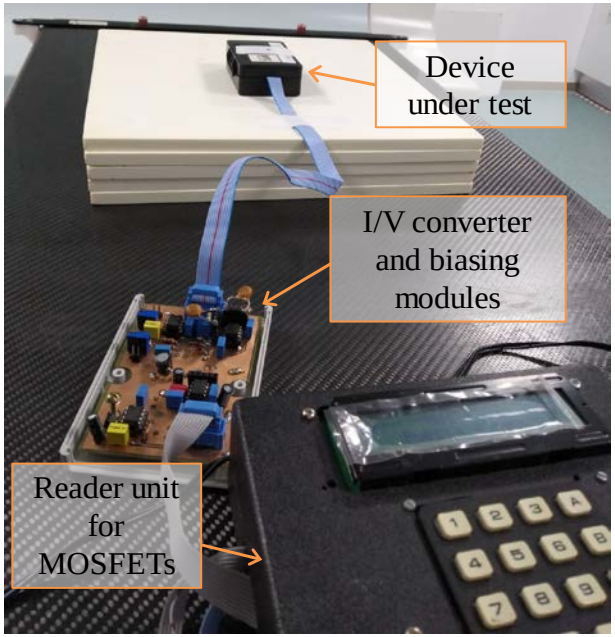


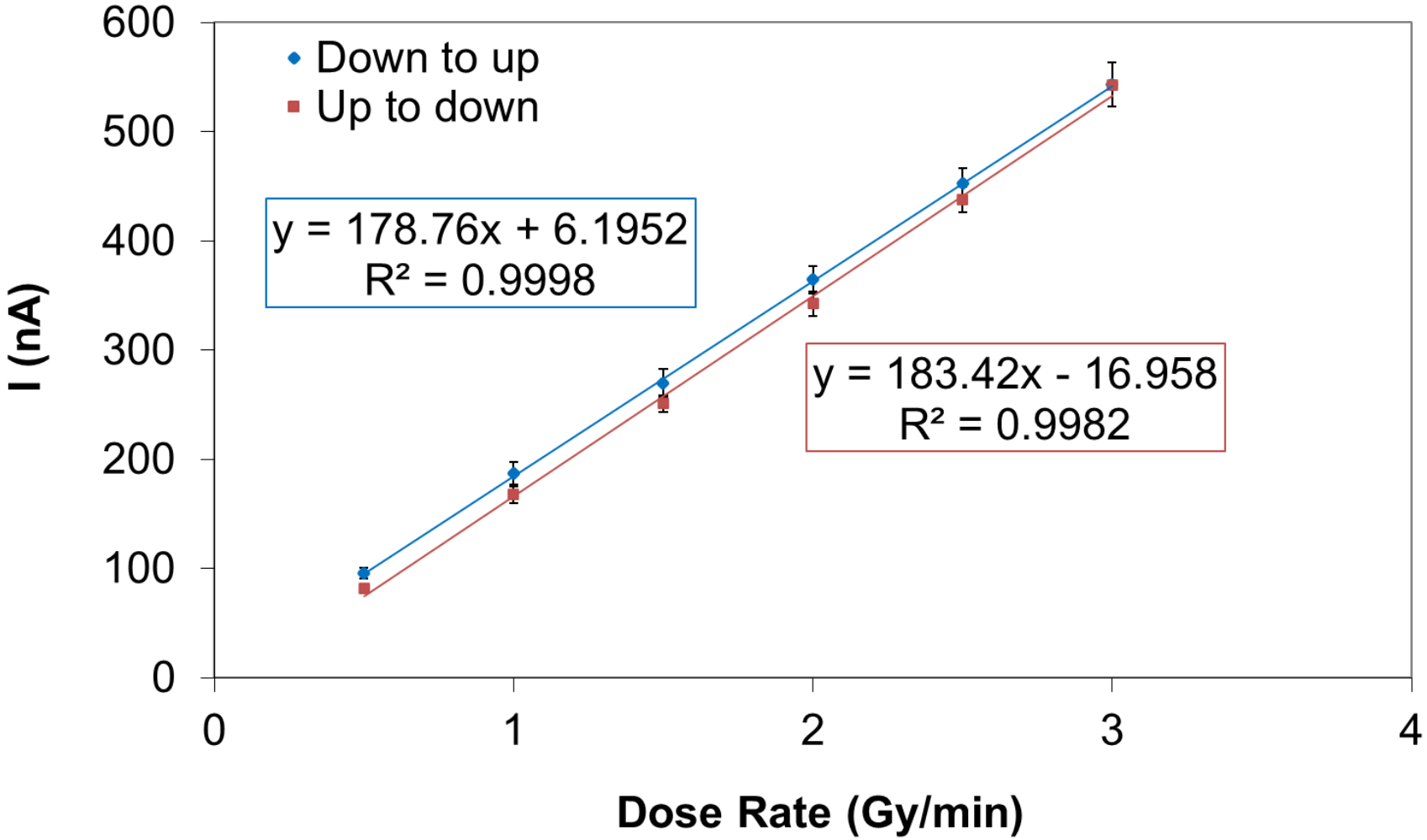
Figure 7. Experimental setup.

Results

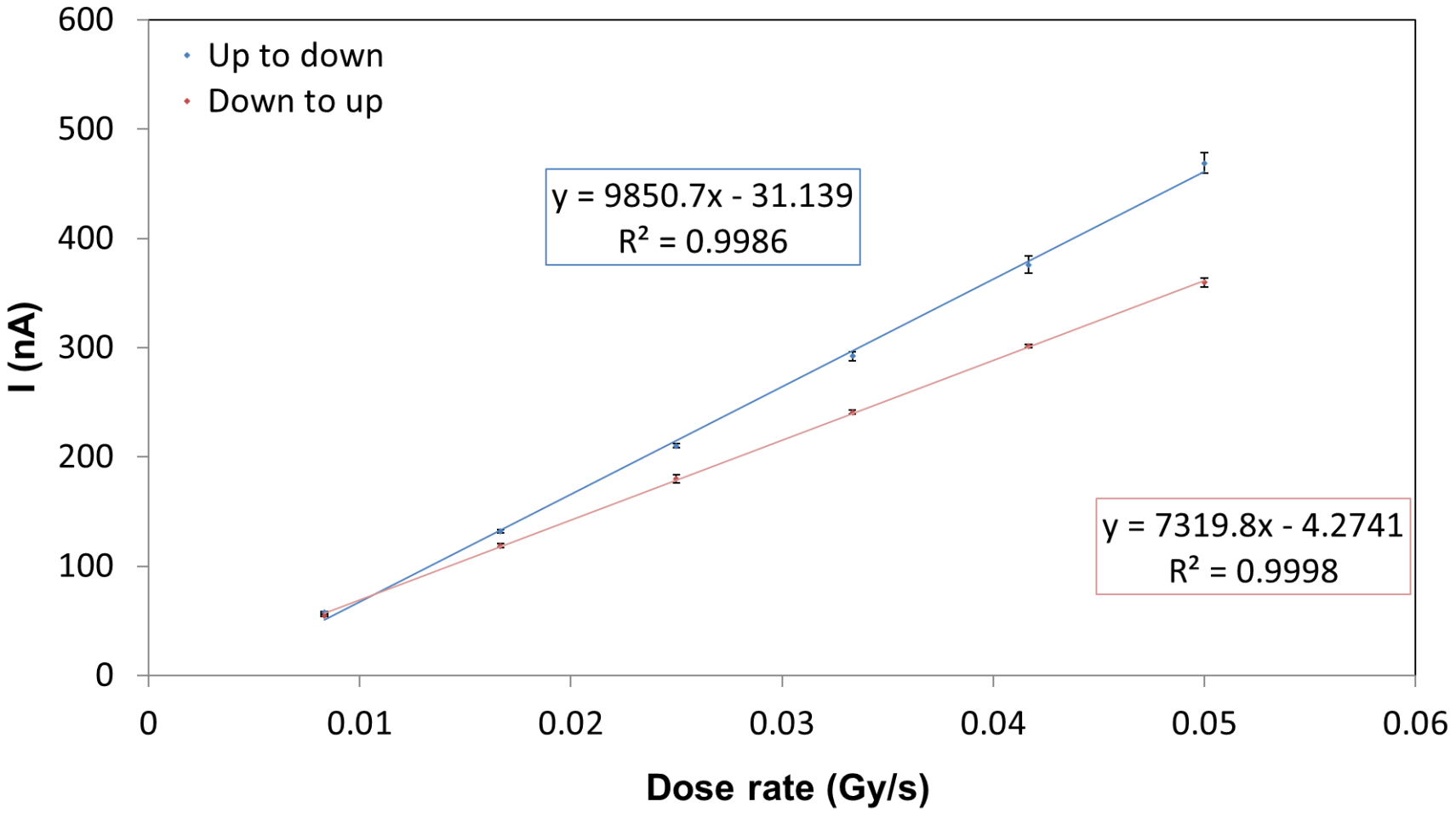
Linear dependences of the current with dose rate were found in all the experiments (bias voltage during irradiation: -10 V) for the following devices:

- OP505:
  High -> Low: (11.01 ± 0.23) µC/Gy (R^2= 0.998).
  Low -> High: (10.73 ± 0.08) µC/Gy (R^2 = 0.9998).
- BPW85B:
  High -> Low: (9.85 ± 0.18) µC/Gy (R^2 = 0.998).
  Low -> High: (7.32 ± 0.05) µC/Gy (R^2= 0.9998).
- VTB8440BH:
  High -> Low: (10.8 ± 0.4) µC/Gy (R^2 = 0.9947).
  Low -> High: (7.7 ± 0.2) µC/Gy (R^2= 0.9970).

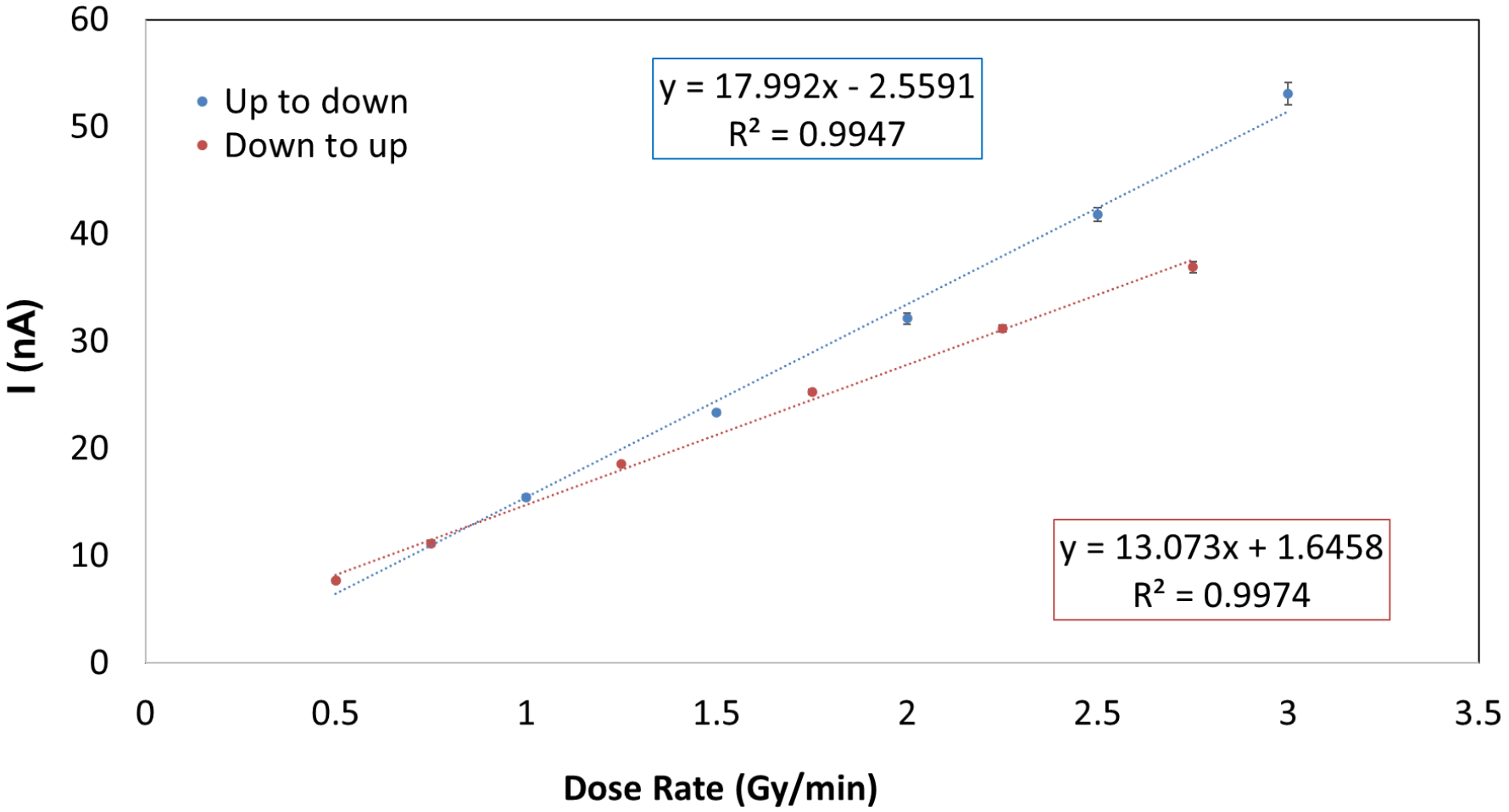
OP505 results



BPW85B results



VTB8440BH results



Conclusions

- The designed reader unit has been successfully tested to measure dose rates in the usual range of radiotherapy treatments.
- The response of the BPW85B and VTB8440BH showed a response degradation higher than 26% after the first 12 Gy.
- The OP505 presented a better response to be used as dose rate sensor with our reader module, and it will be further characterized with photon beams of 6 and 12 MV.
- The current tasks are focused on designing a specific reader unit for dose measurements using the topology of the I/V converter described in the present work and characterizing another model of photodiode.

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Acknowledgments

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