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A new dosimeter based on *real-time* spectroscopy of radiochromic films

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INTRODUCTION: REAL-TIME DOSE MONITORING

THE *REAL-TIME* DOSE MEASUREMENT IS A CRUCIAL ASPECT WHEN THE RELATION **DOSE-DAMAGE** IS NEEDED

APPLICATION FIELDS

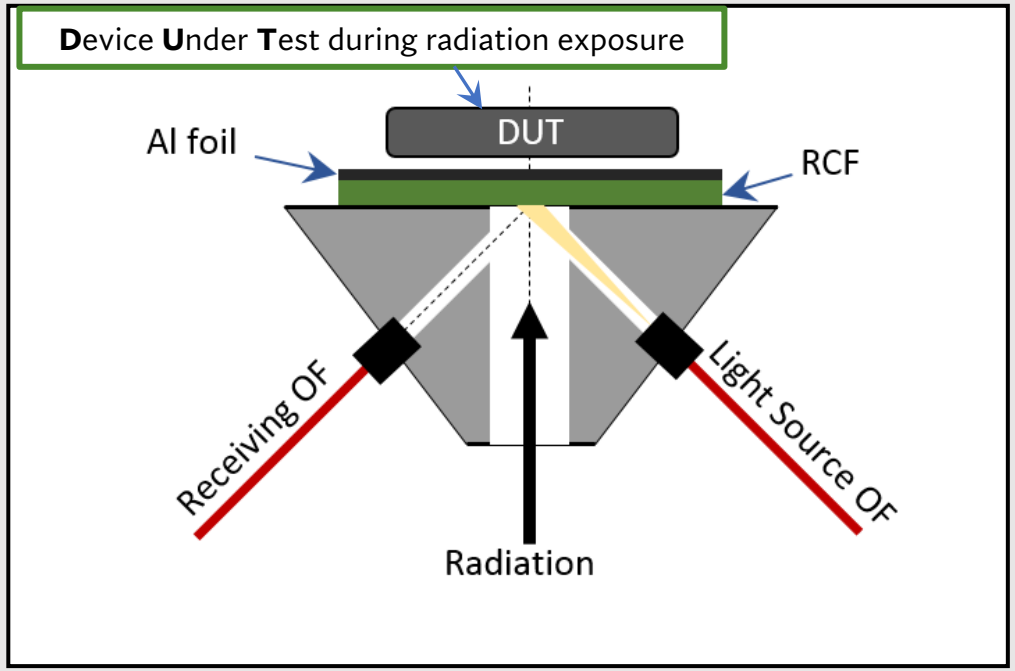
- HIGH ENERGY PHYSICS EXPERIMENT (MONITORING OF DOSE IMPARTED TO CRITICAL SETUP COMPONENTS)
- ENVIRONMENTAL DOSE MONITORING
- **RADIATION HARDNESS ASSURANCE** (RHA) TEST OF ELECTRONIC DEVICES (EX. FOR SPACE APPLICATIONS)

DOSIMETER **REQUIREMENTS** FOR REAL TIME DOSE MEASUREMENT

- INSTANT RESPONSE TO RADIATION FIELDS VARIATIONS
- NEGLIGIBLE PERTURBATION OF THE RADIATION FIELD
- COMPACT DIMENSIONS ARE TO BE PREFERRED FOR A BETTER ADJUSTMENT TO THE EXPERIMENTAL NEED

METHOD: THE DOSIMETER WORKING PRINCIPLE

THE DOSIMETER IS BASED ON THE REAL-TIME READING OF RADIOCHROMIC FILMS (**RCF**) WITH A SPECTROSCOPIC METHOD



SKETCH OF THE DOSIMETER. TWO OFs ARE FIXED ON AN ALLUMINUM HOLDER. THE SETUP ALLOWS TO READ THE LIGHT SPECTRUM OF A RCF AS IT DARKENS DUE TO THE RADIATION FIELD.

- AN OPTICAL FIBER (**OF**) DRIVES THE LIGHT FROM A LIGHT SOURCE TO THE RCF
- A RECEIVING **OF**, CONNECTED TO A SPECTROMETER, ALLOWS TO READ THE REFLECTED LIGHT SPECTRUM

DURING THE IRRADIATION

THE REFLECTED LIGHT SPECTRUM OF THE **RCF** IS COLLECTED REAL-TIME BY THE **OF**

↓

THE **RCF** DARKENS AS A FUNCTION OF THE DOSE

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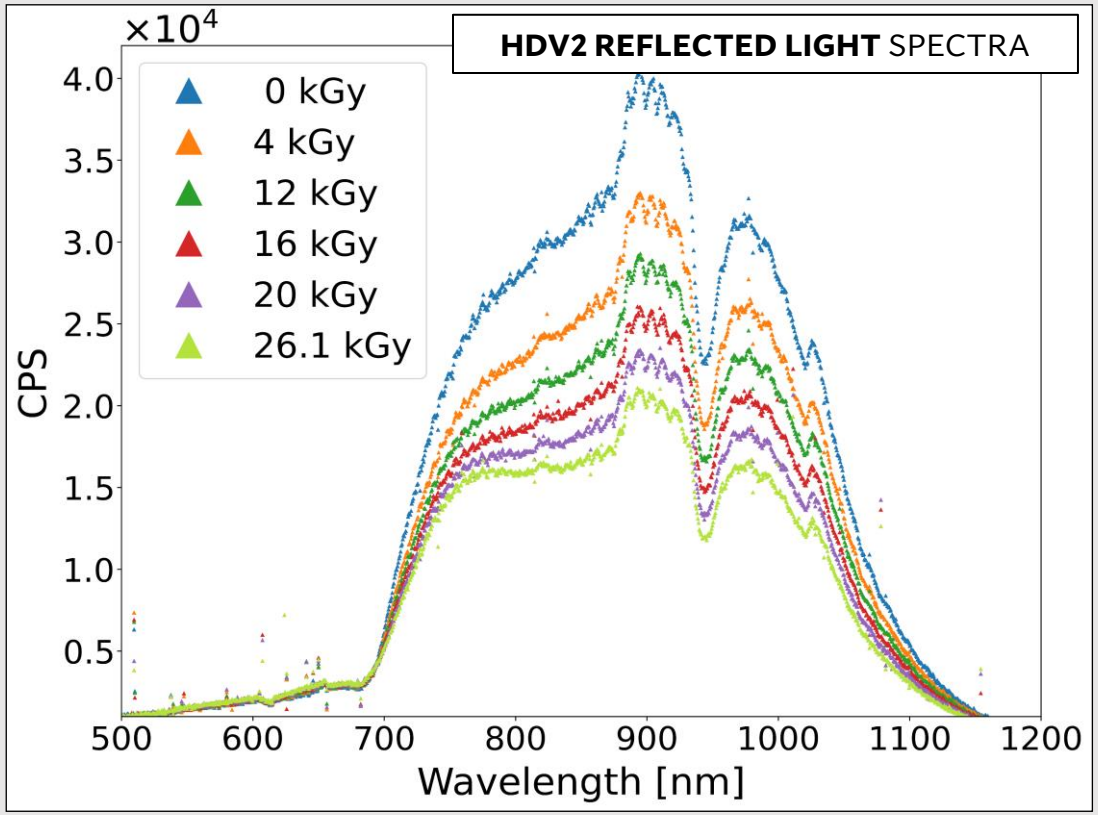
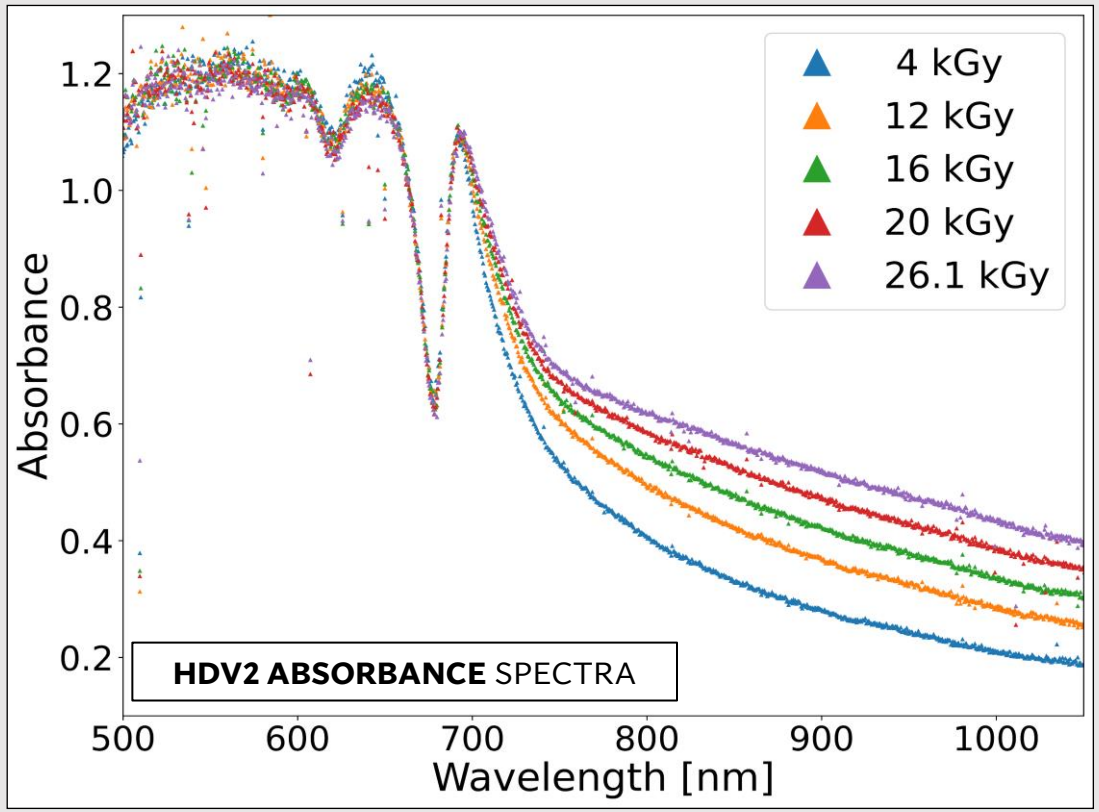
THE INTENSITY OF THE REFLECTED LIGHT SPECTRUM DECREASES OF A QUANTITY RELATED TO THE ACCUMULATED DOSE I.E. THE DOSE ON THE DEVICE UNDER TEST (**DUT**)

METHOD: THE DOSIMETER WORKING PRINCIPLE

THE INTENSITY DECREASES DUE TO THE ACCUMULATED DOSE ON THE **RCF**.
EACH SPECTRUM IS CALIBRATED THROUGH AN EXTERNAL DOSIMETER.



$$A_i = log\ \frac{cps\ (Dose_0)}{cps\ (Dose_i)}$$



THE ABSORBANCE GIVES THE DIFFERENCE OF A SPECTRUM AT A GIVEN DOSE, RESPECT TO THE SPECTRUM AT THE INITIAL DOSE

METHOD: THE DOSIMETER WORKING PRINCIPLE

THE INTENSITY DECREASES DUE TO THE ACCUMULATED DOSE ON THE **RCF**.
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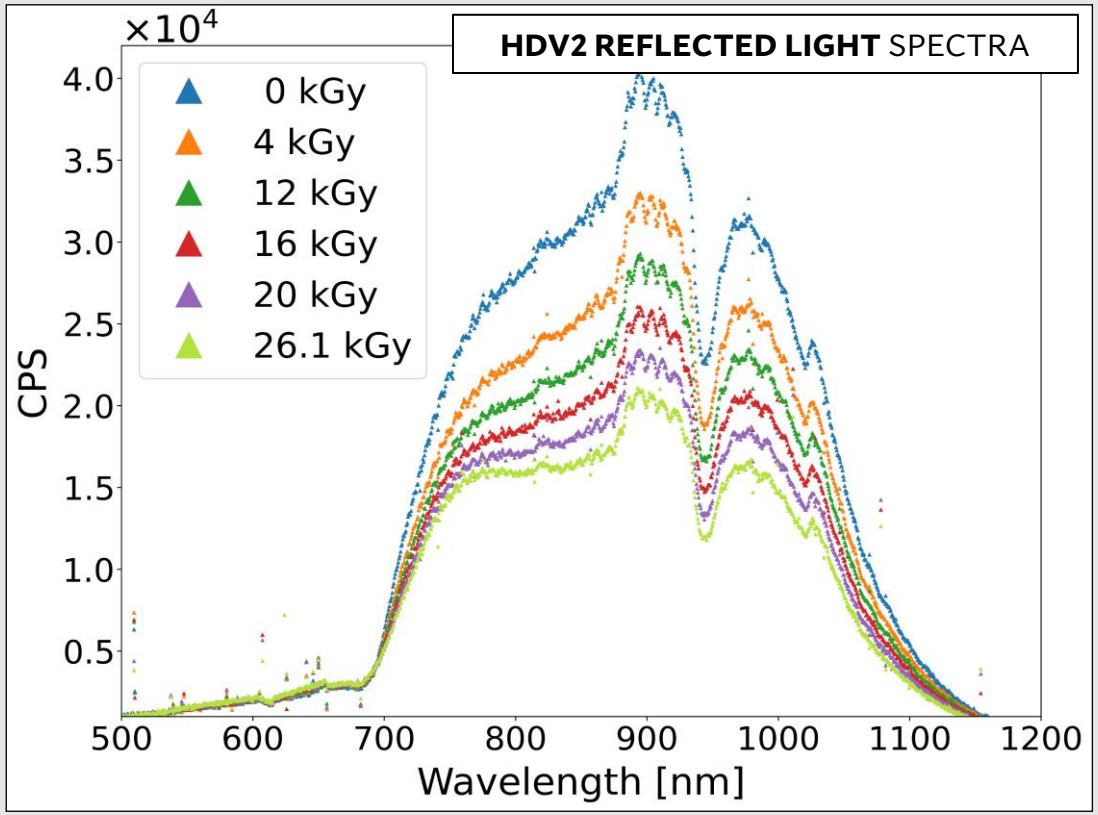

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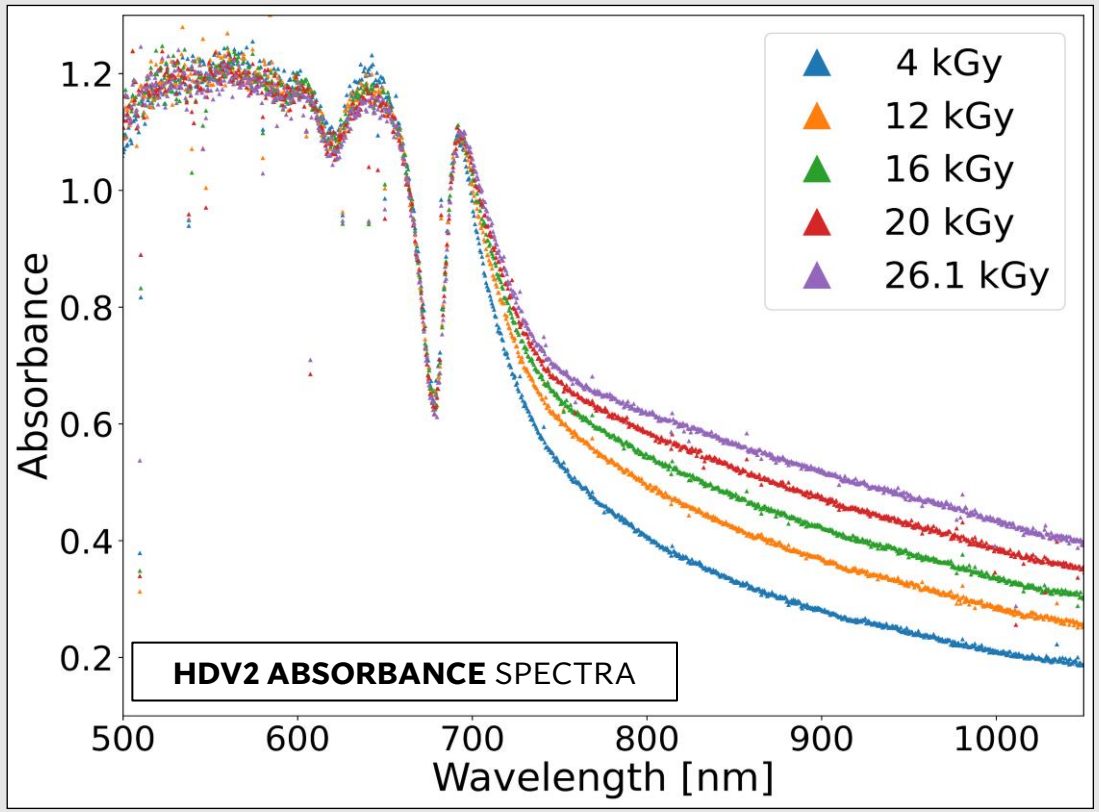
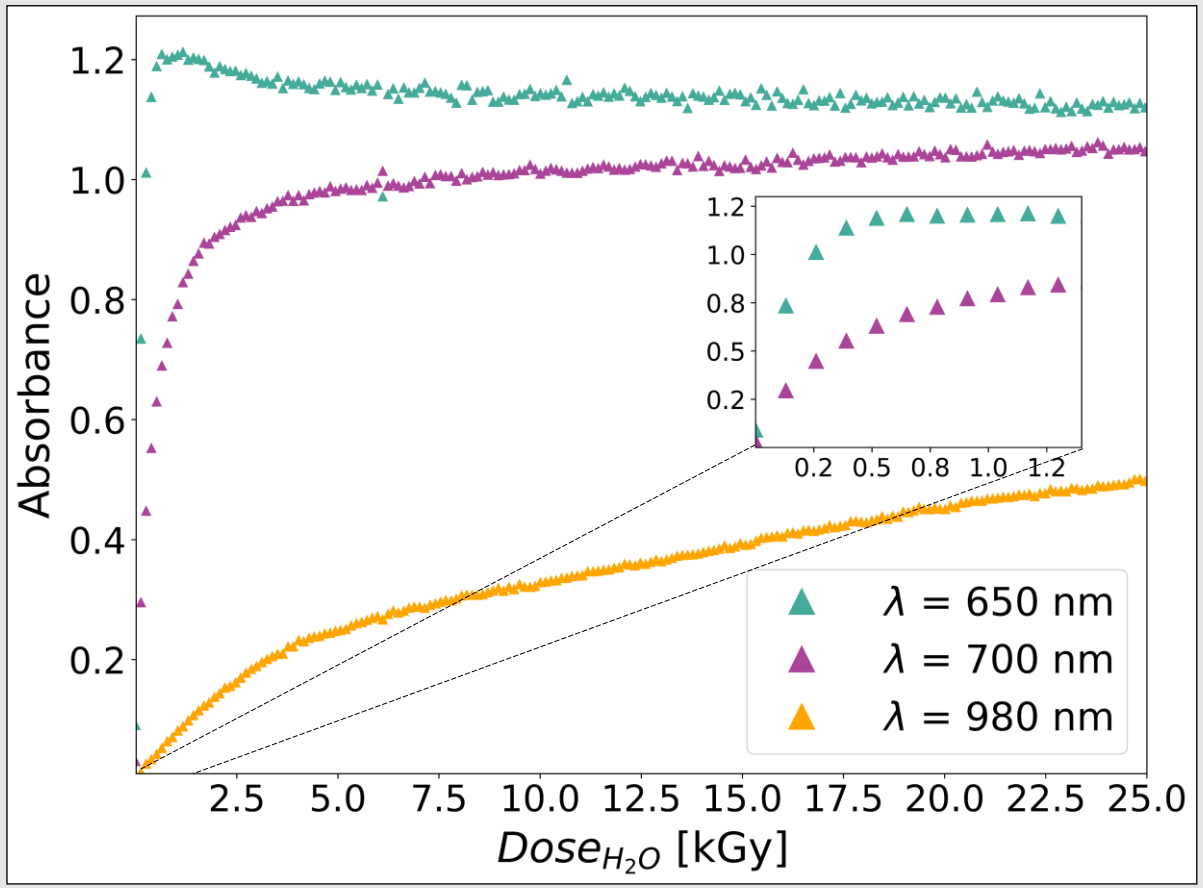


BY THE ANALYSIS OF THE ABSORBANCE SPECTRA IT IS POSSIBLE TO EXTRACT REAL-TIME THE VALUE OF THE IMPARTED DOSE ON THE DOSIMETER, MEANING THE DOSE ON THE DEVICE

METHOD: THE DOSIMETER WORKING PRINCIPLE



THE RESPONSE OF THE DOSIMETER DEPENDS ON BOTH THE ACCUMULATED DOSE AND THE WAVELENGTH OF THE SPECTRUM

FOR A GIVEN WAVELENGTH, THE ABSORBANCE INCREASES UNTIL IT REACHES A MAXIMUM VALUE (SATURATION POINT) CORRESPONDING TO A GIVEN ACCUMULATED DOSE

THE SATURATION POINT IS DIFFERENT FOR DIFFERENT WAVELENGHT REGIONS

THE DYNAMIC DOSE RANGE OF THE DOSIMETER DEPENDS ON THE WAVELENGHT AT WHICH THE ANALYSIS IS PERFORMED AND ON THE RCF USED FOR THE DOSIMETER

METHOD: THE DOSIMETER WORKING PRINCIPLE

RCF used	NOMINAL RCF RANGE	EXP. RANGE
Gafchromic EBT3	0.1 – 20 Gy	1.4 – 210 Gy
Gafchromic HDV2	0.01 – 1 kGy	0.13 – 26.1 kGy
Risø B3	0.5 – 200 kGy	1 – 800 kGy

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THE DYNAMIC DOSE RANGE OF THE DOSIMETER DEPENDS ON THE WAVELENGHT AT WHICH THE ANALYSIS IS PERFORMED AND ON THE **RCF** USED FOR THE DOSIMETER

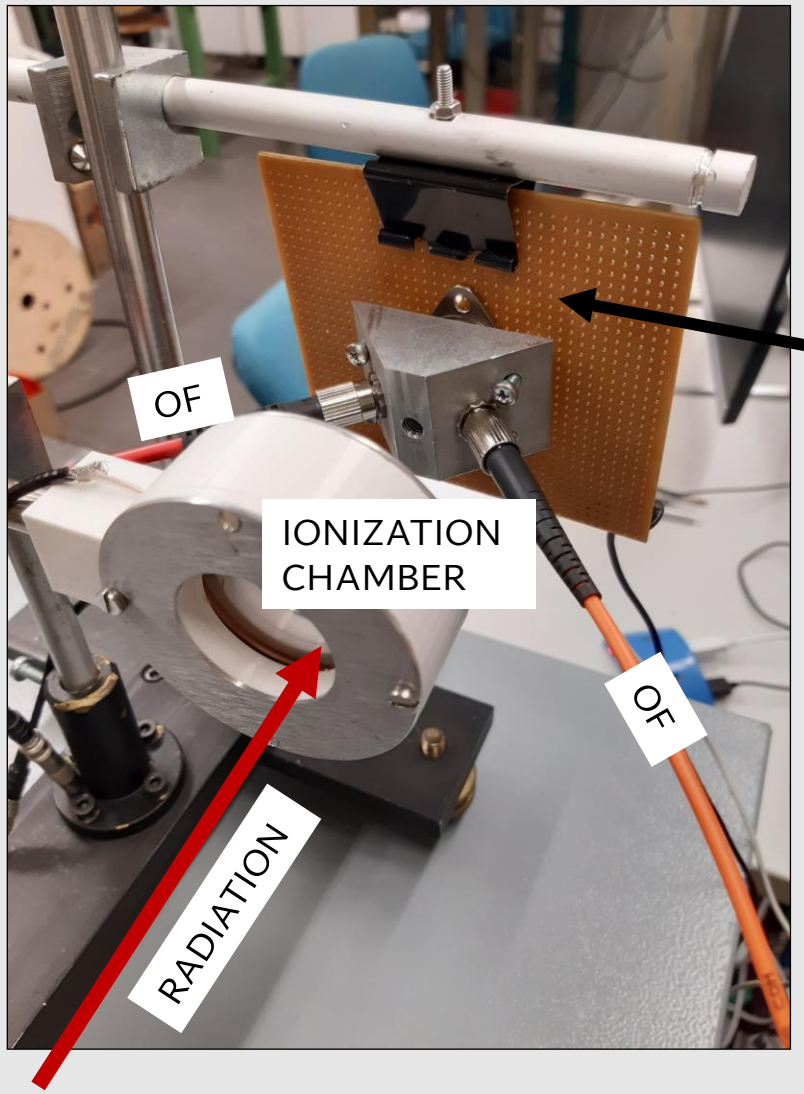
THE DOSE RANGE OF THE DOSIMETER EXTRACT THROUGH THIS METHOD IS WIDER THAN THE NOMINAL DOSE RANGE OF THE **RCF**s

RADIATION HARDNESS TEST

THE RADIATION HARDESS TESTS HAS THE PURPOSE OF MONITORING THE PERFORMANCE OF AN ELECTRONICAL DEVICE WHILE IRRADIATED, AND TO RELATE ANY MALFUNCTIONING TO THE ACCUMULATED DOSE

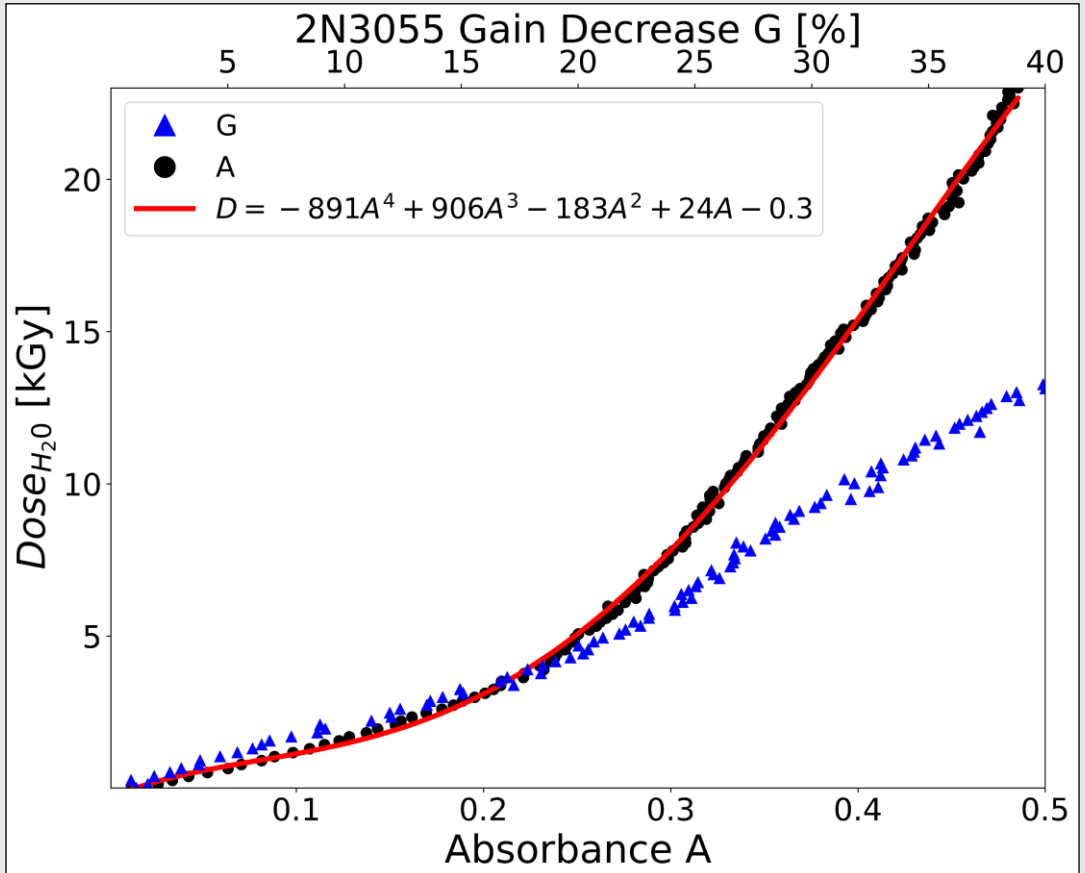
FOR THESE KIND OF TESTS IT IS IMPORTANT TO KNOW THE RELATION BETWEEN THE DAMAGE AND THE EXACT IMPARTED DOSE

IT IS CRUCIAL TO KNOW THE DOSE IMPARTED AT ANY TIME

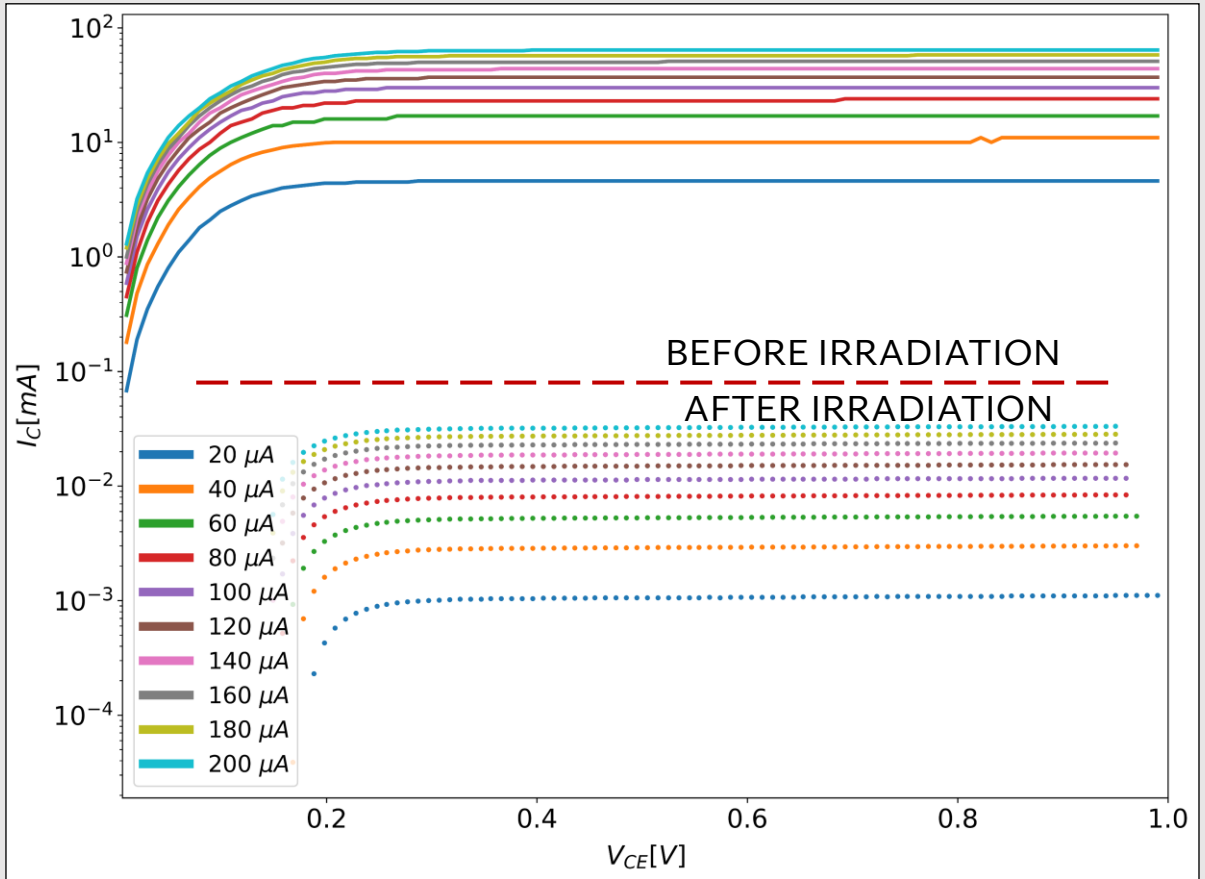


2N3055 TRANSISTOR. THE LID HAS BEEN REMOVED TO EXPOSE THE SENSITIVE PART

RADIATION HARDNESS TEST - RESULTS



THE FIGURE SHOWS THE RELATION BETWEEN THE ABSORBANCE MEASURED WITH OUR SETUP, THE DOSE (CALIBRATED WITH AN EXTERNAL DEVICE), AND THE GAIN DECREASE **DURING** THE IRRADIATION



THE CHARACTERISTICS OF THE TRANSISTOR WERE MEASURED BEFORE AND AFTER THE IRRADIATION TO BE ABLE TO QUANTIFY THE RADIATION DAMAGE

CONCLUSIONS

THIS NEW DOSIMETER IS BASED ON THE REAL-TIME SPECTROSCOPIC ANALYSIS OF THE RCF SPECTRA AND ALLOWS TO RELATE THE ABSORBANCE OF THE SPECTRA TO THE ACCUMULATED DOSE

THE DOSE RANGE OF THE DOSIMETER DEPENDS AND THE RCF USED AND ON THE WAVELENGTH CHOOSEN FOR THE ANALYSIS OF THE SPECTRUM

THE RESULTING DOSE RANGE IS EXTREMELY WIDE:
FROM FEW Gy (WITH EBT3), TO MGy (WITH B3)

THE RHA TEST PERFORMED HAS DEMONSTRATED THAT THIS DOSIMETER ALLOWS TO RELATE THE ACCUMULATED DOSE ON A DEVICE TO THE INDUCED DAMAGE

IN CONCLUSION, THIS DOSIMETER IS ADDRESSED TO RADIATION HARDNESS TEST. HOWEVER FURTHER DEVELOPMENTS CAN BE FORESEEN IN THE DOSIMETRY MONITORING FOR RADIOTHERAPY APPLICATION