Innovative real-time dosimetry method with radiochromics

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on behalf of Optical Fiber Dosimetry Working Group

Outline

- Dosimetry and related applications
- Radiochromic films (RCF's)
- Read-out methods

- Optical fiber RCF real-time read-out method (National Patent filed)
- Results and future perspectives
- TTT-3MV of University of Naples Federico II

Dosimetry and related applications

- Radiation Protection
- Environmental monitoring of radiation levels

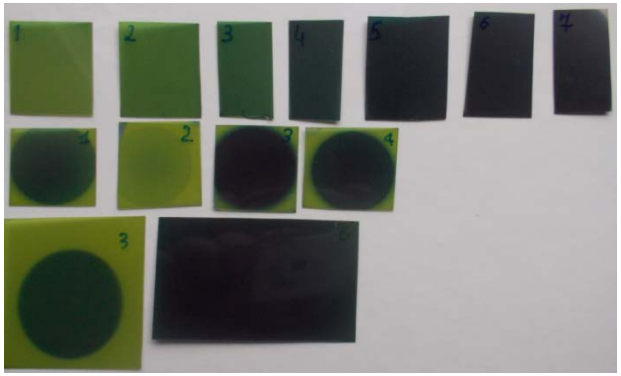
- Medical Physics
- Radiobiology: Dose-effect curves

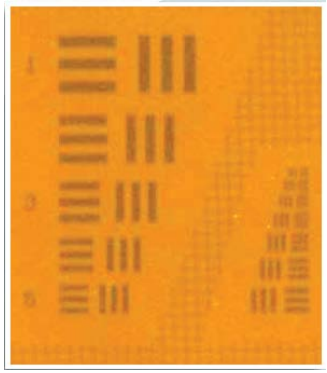
- Industrial applications: radiation processing (food irradiation, sterilization, cross-linking of materials…)
- Radiation hardness (space applications and HEP instrumentation)
- Beam diagnostics

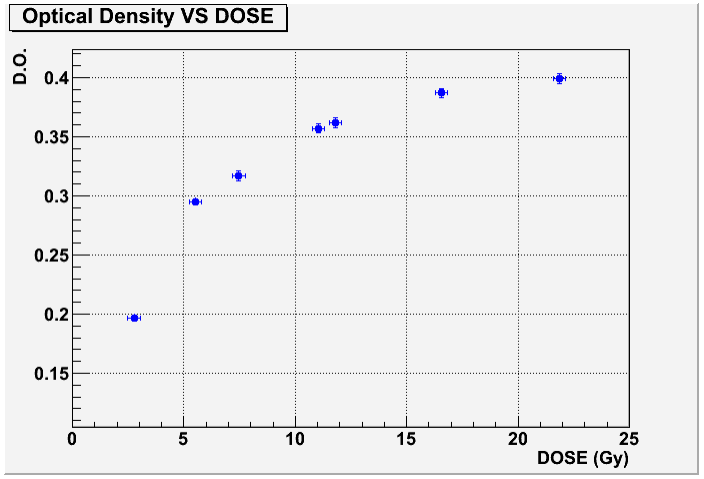
High precision and accuracy, as well as real-time information are strongly required

Radiochromic films

Radiochromic films consist of a single or double layer of radiation-sensitive organic microcrystal monomers, on a thin polyester base with a coating





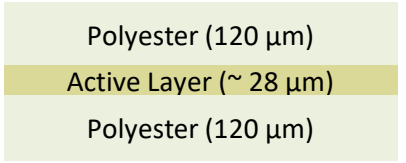


- Self developing and insensitive to ambient light
- Excellent spatial resolution
- Direct visualization of the radiation field
- Accuracy of dose measurement
- Permanent absolute values of dose
- Easy of handling and data analysis
- Wide range of dose

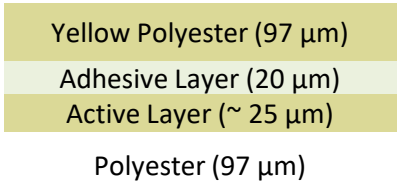
- A calibration is needed

Radiochromic film types

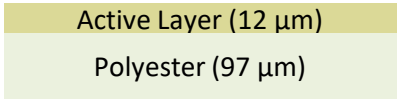
- Gafchromic EBT3 (1 cGy - 40 Gy)



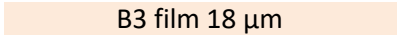
- Gafchromic XR -QA2 (0.1-20 cGy)
  -CT2 (0.1-20 cGy)
  -M2 (0.1-20 cGy)
  -RV3 (0.05-15 cGy)



- Gafchromic HDV2 (10 Gy-1000 Gy)



- GEX Corp. B3 films (1-150 kGy)

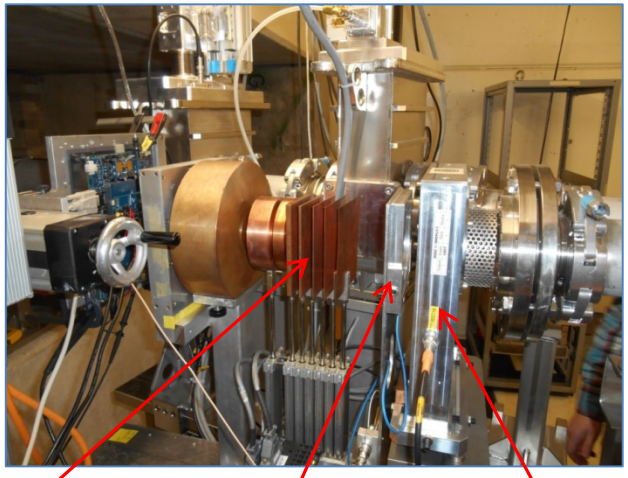


- FWT-60 films (0.5-200 kGy)

High dose applications

Radiation hardness (Space, HEP and medical physics instrumentation)

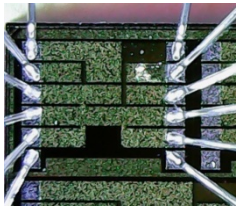
PSI PIF facility



Copper degraders

Mylar window

Ionization chamber

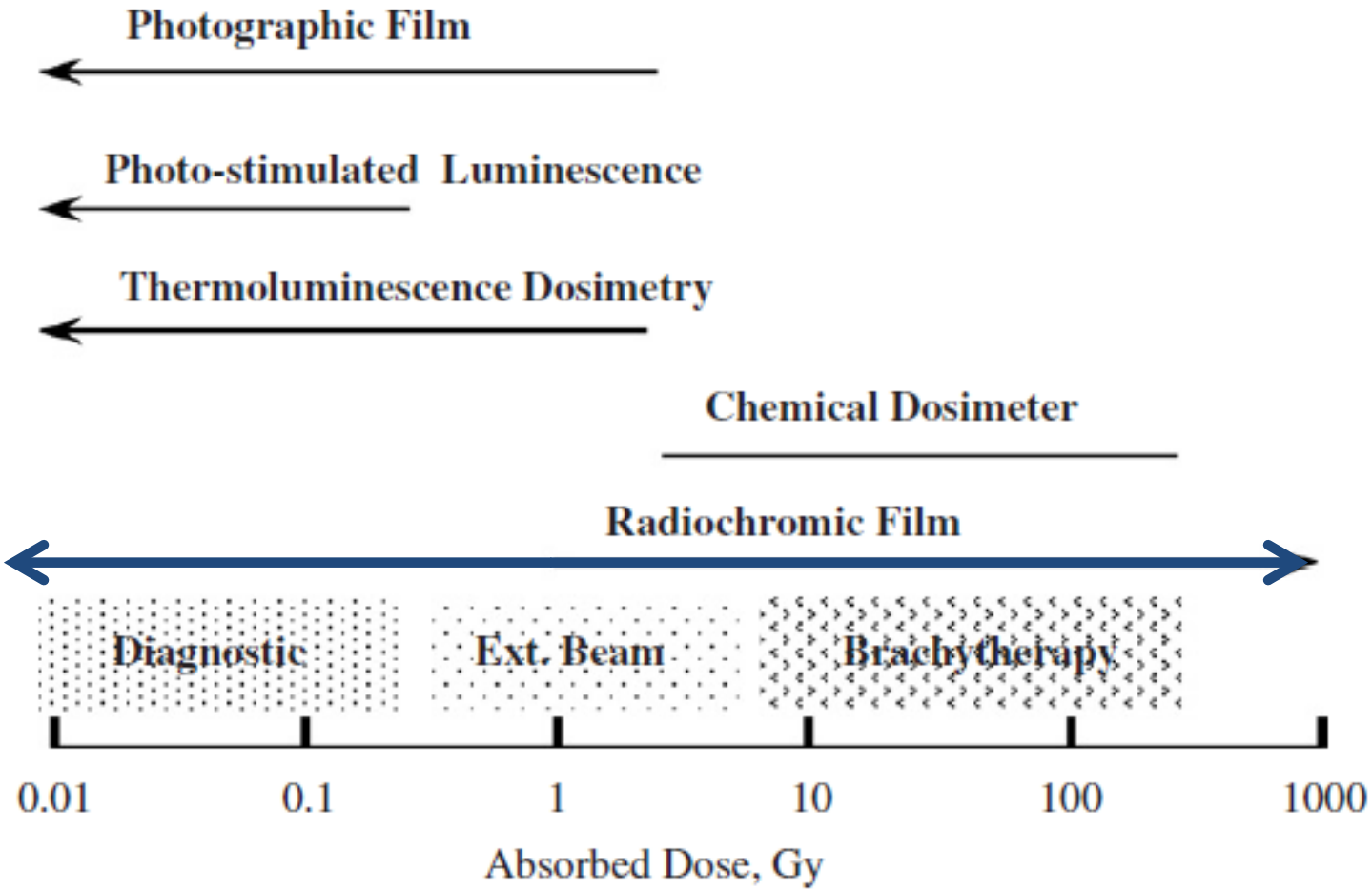


CNA Sevilla

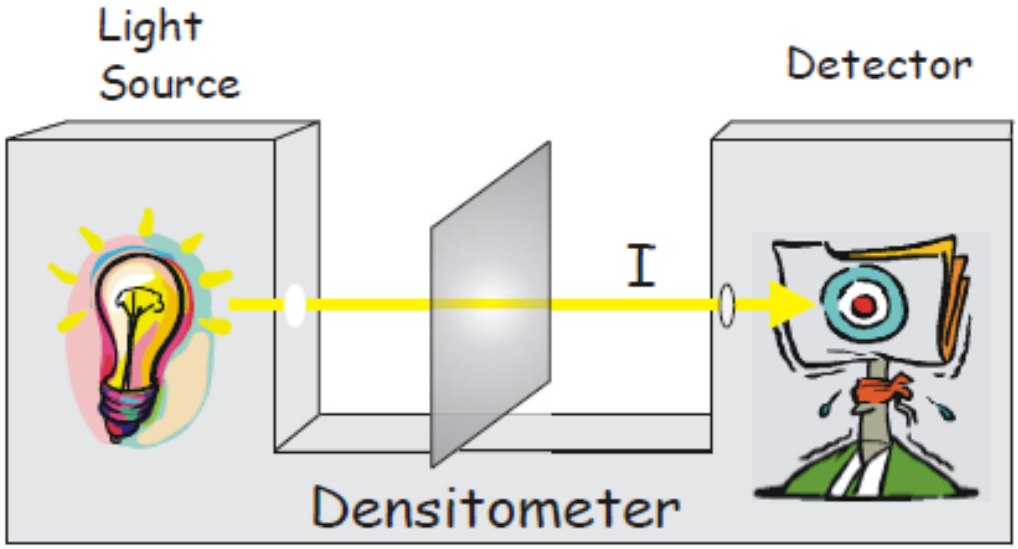
Beam spot on RCF

About 1 m air

Medical applications



How to measure the RCF's darkness



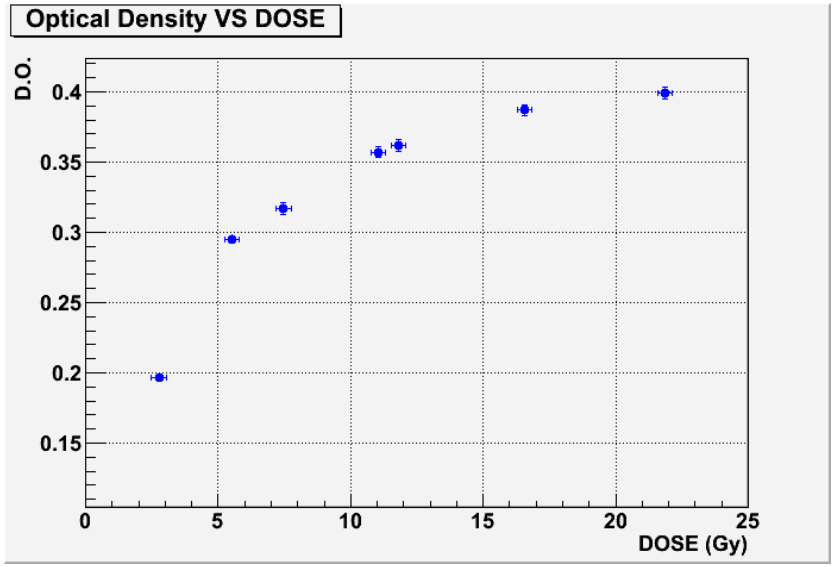
Transmission = $\frac{I}{I_0}$

$$OD \equiv log_{10} \frac{I_0}{I}$$

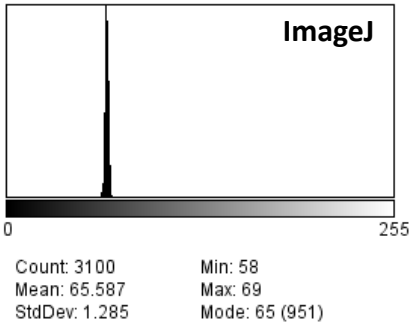
RCF's read-out instrumentation

1) Ddensitometer

Optical density

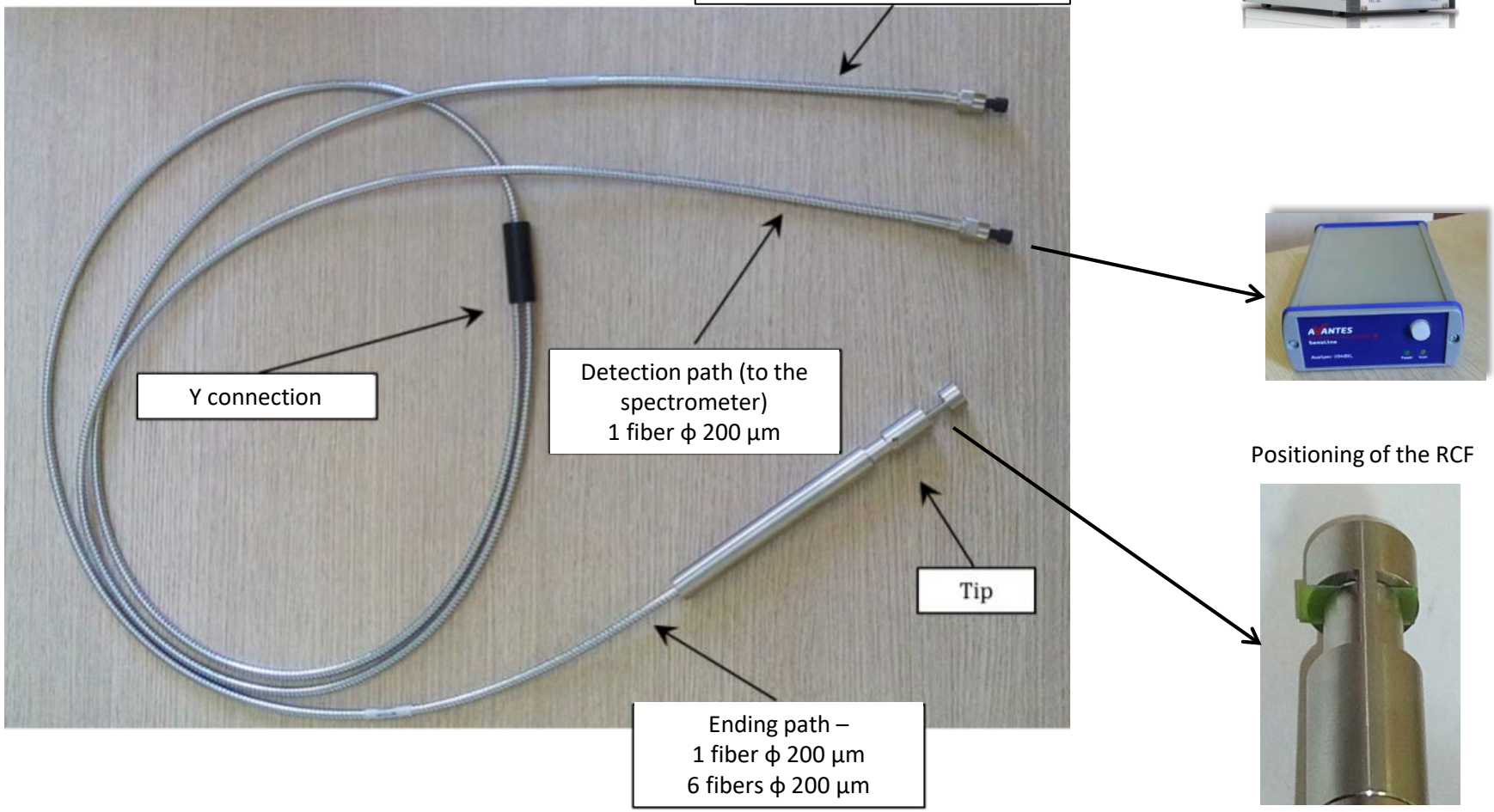


2) Flat-bed scanner

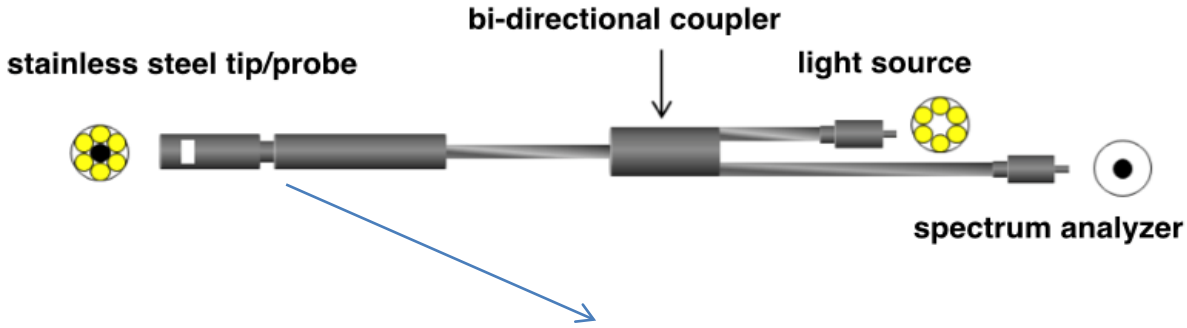


- **Current commercial instruments allow the knowledge of integral value of dose but not the trend during time !**
- **The optical fiber RCF read-out method overcomes this intrinsic limitation**

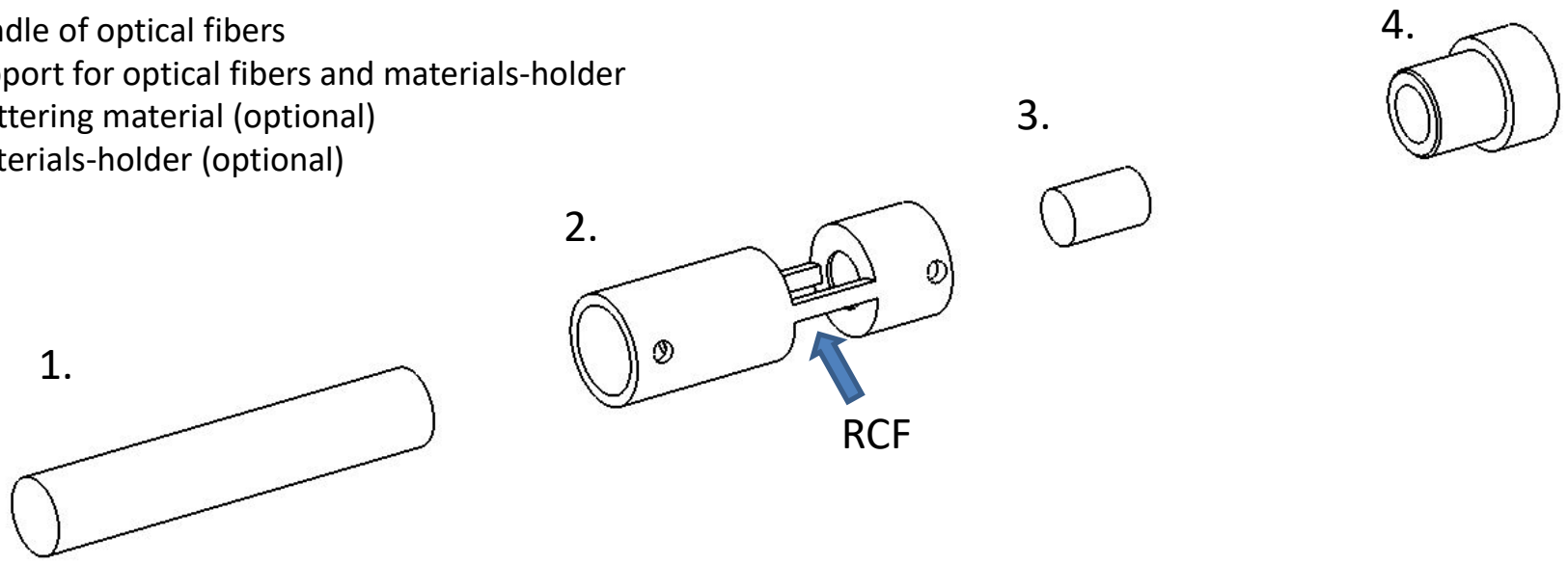
Optical fiber RCF real-time read-out method



Design of mechanical elements – plastic materials

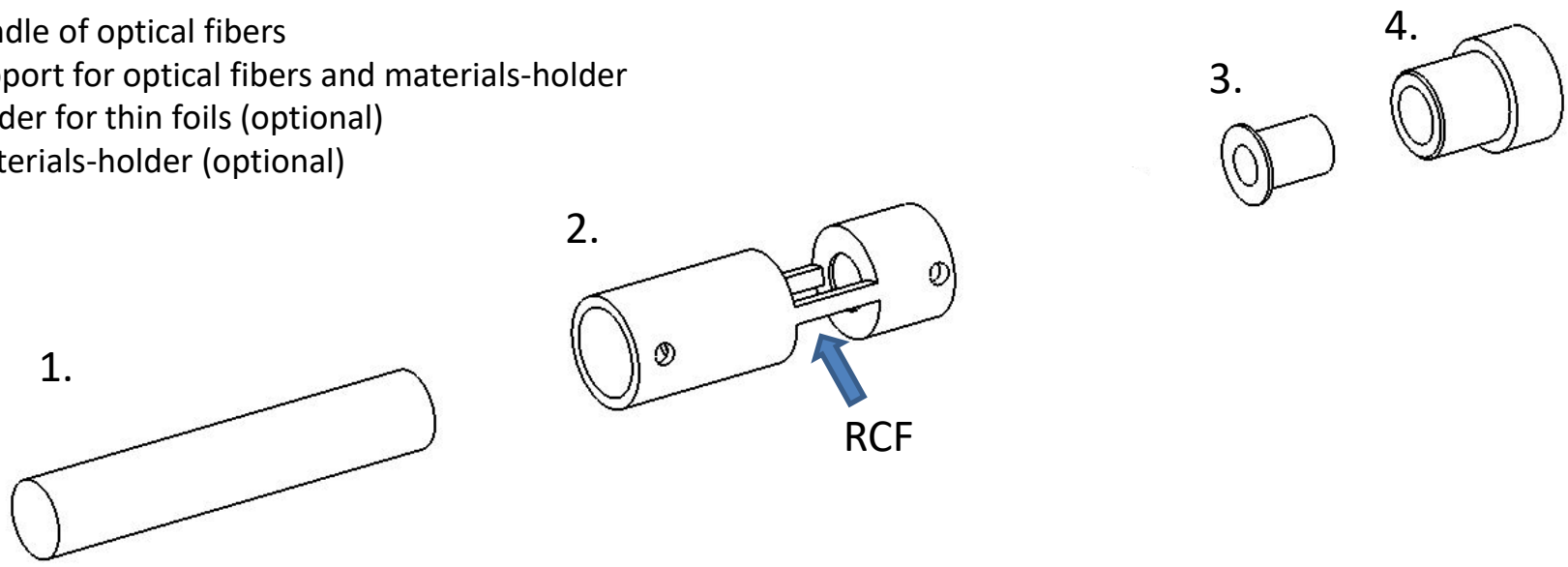


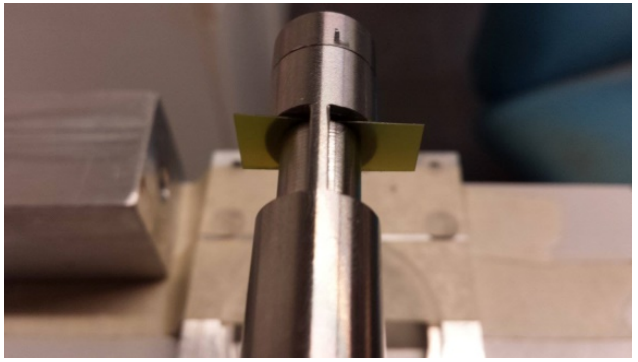
1. Bundle of optical fibers
2. Support for optical fibers and materials-holder
3. Scattering material (optional)
4. Materials-holder (optional)



Design of mechanical elements – thin foils

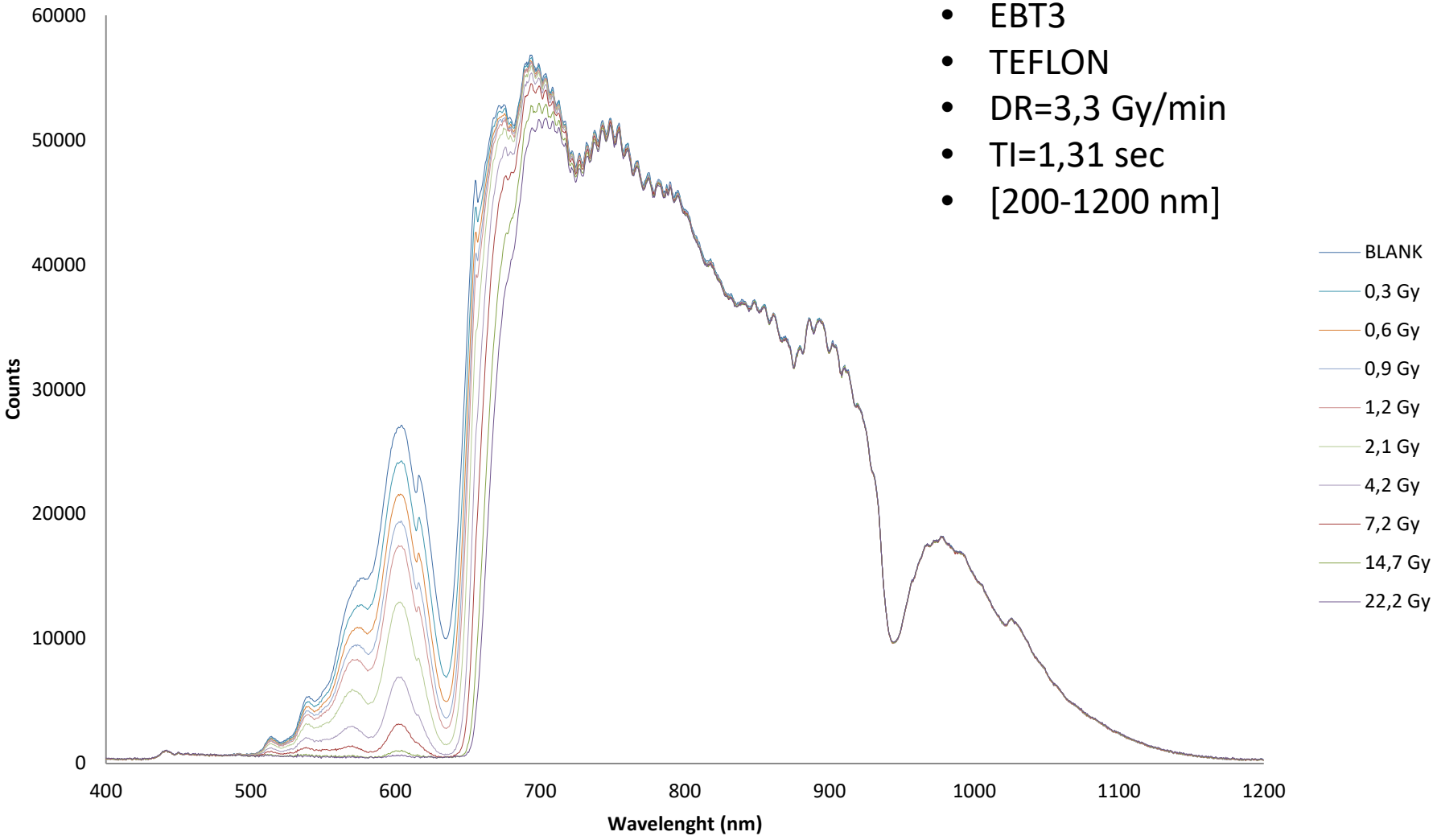
1. Bundle of optical fibers
2. Support for optical fibers and materials-holder
3. Holder for thin foils (optional)
4. Materials-holder (optional)





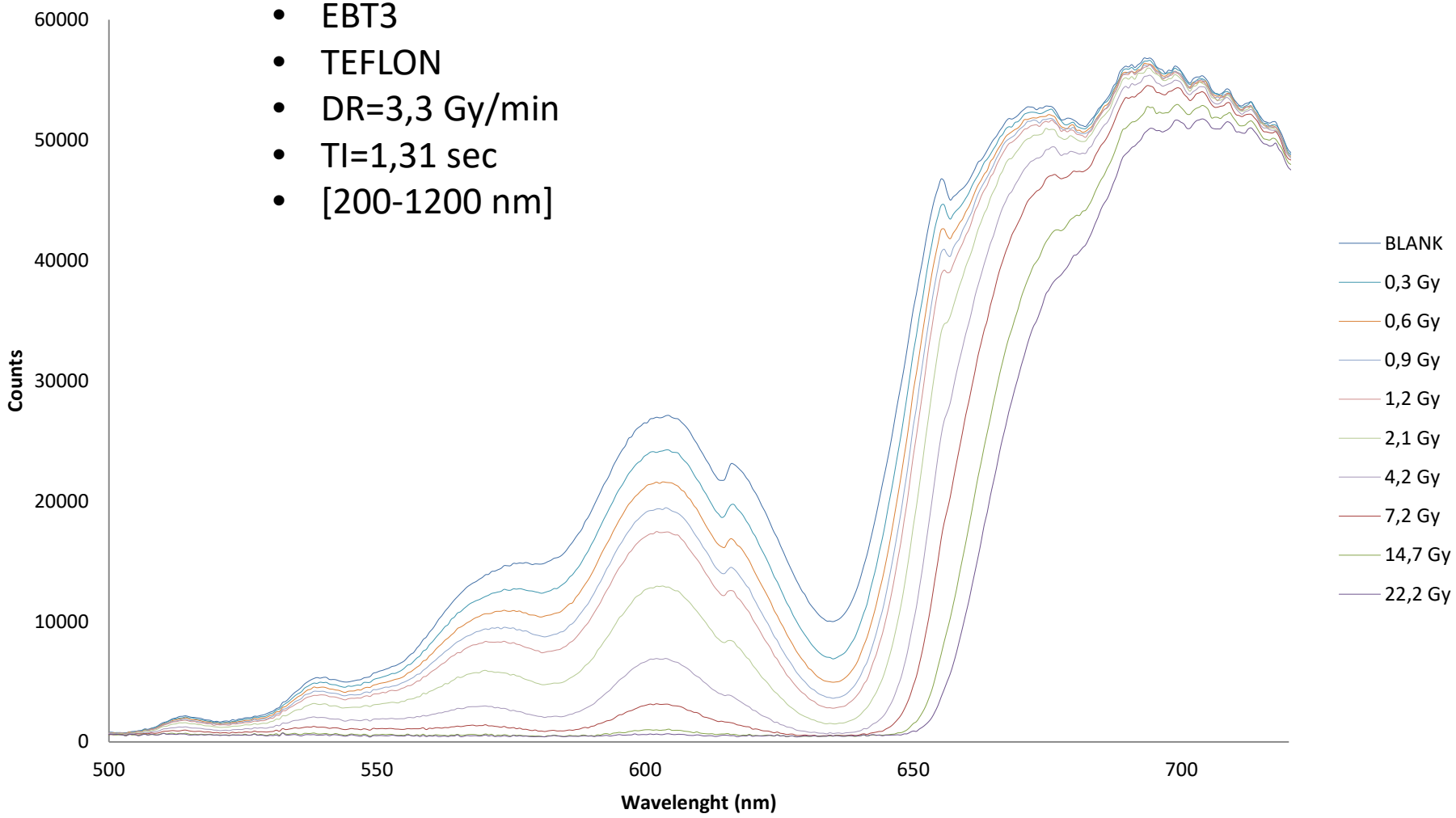
Irradiation with 60-Co gamma cell 3.3 Gy/min

- EBT3
- TEFLON
- DR=3,3 Gy/min
- TI=1,31 sec
- [200-1200 nm]

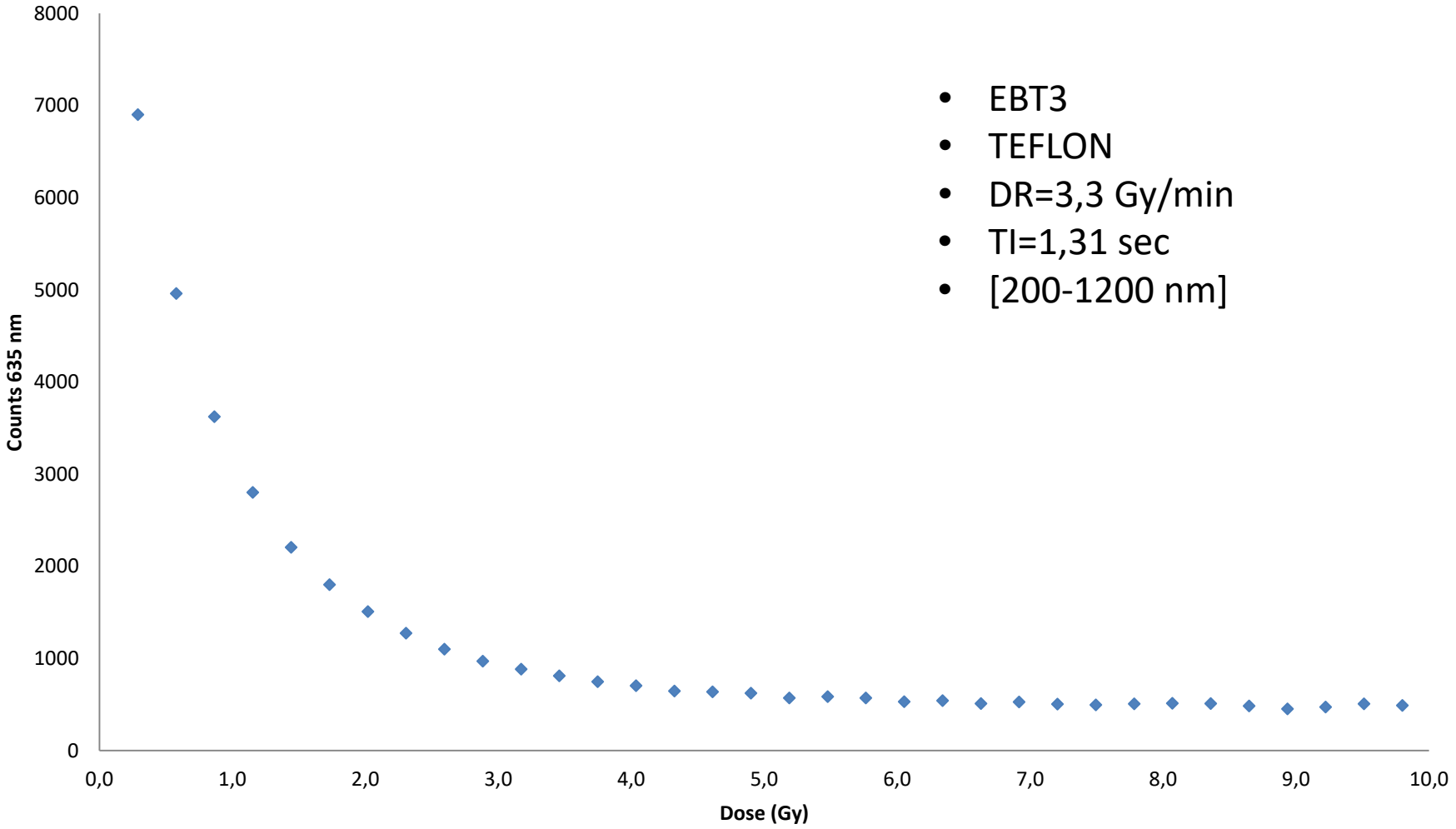


Zoom in [500-700] nm

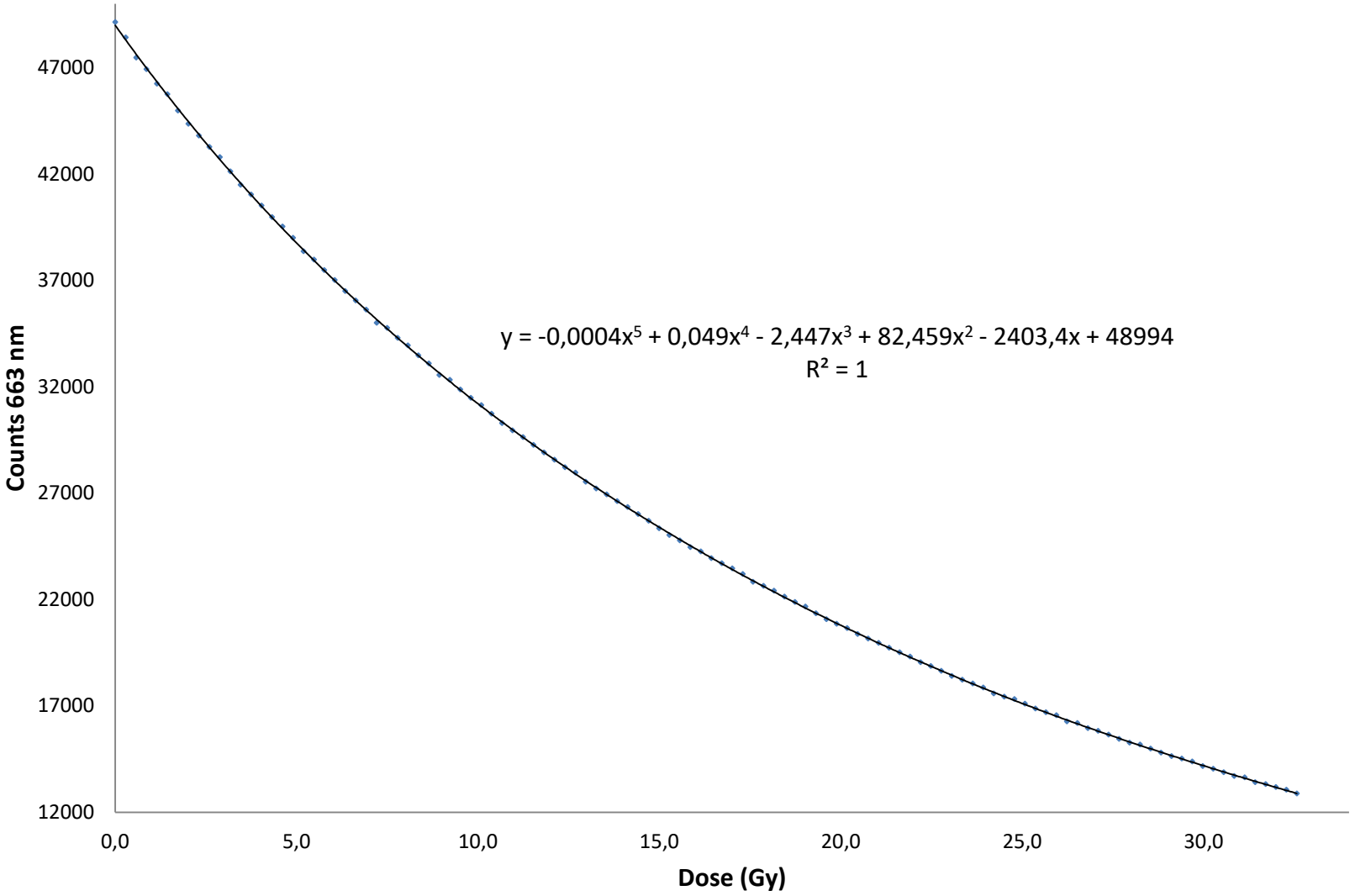
- EBT3
- TEFLON
- DR=3,3 Gy/min
- TI=1,31 sec
- [200-1200 nm]



EBT3 Calibration → Counts 635 nm

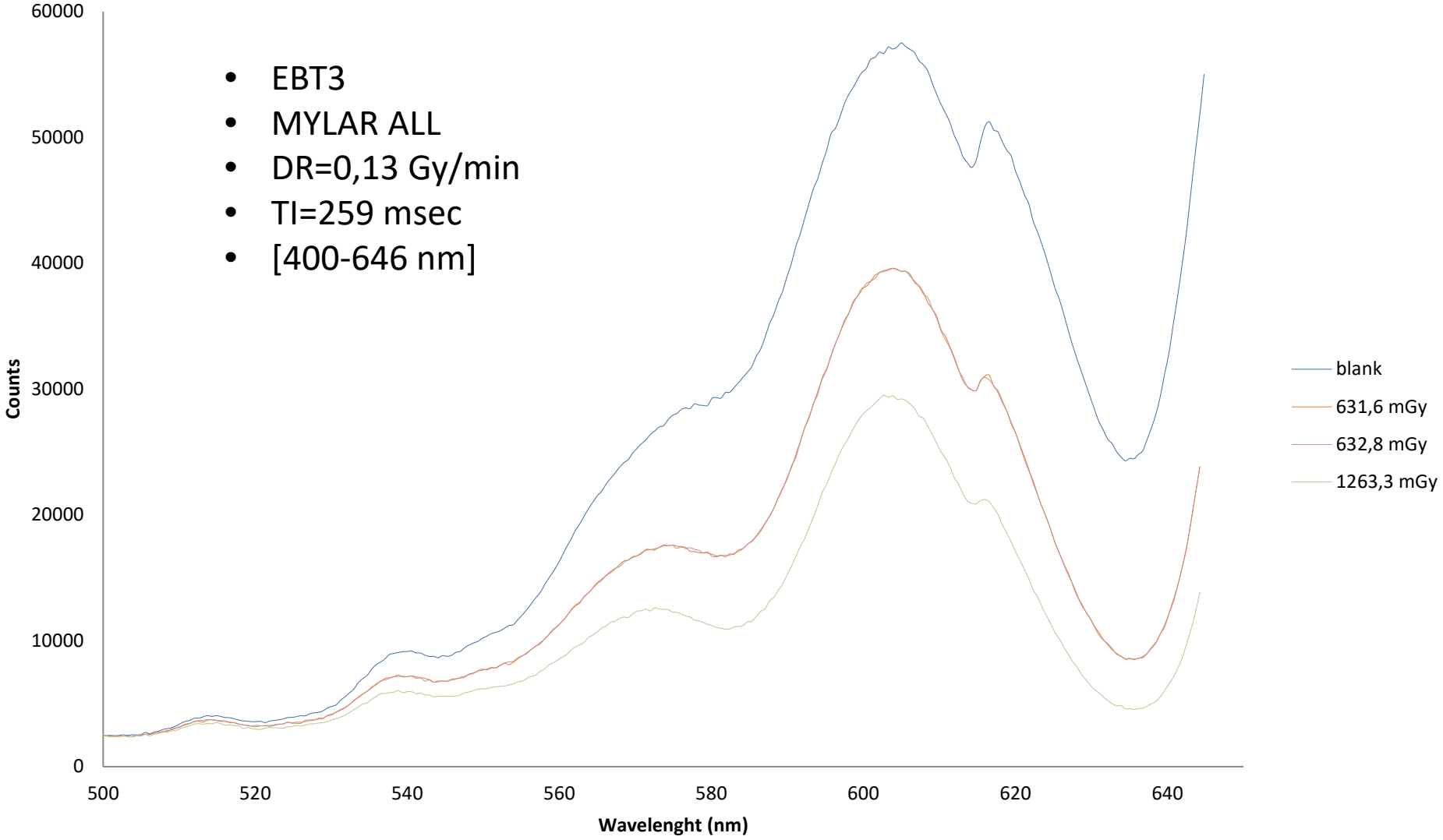


EBT3 Calibration → Counts 663 nm

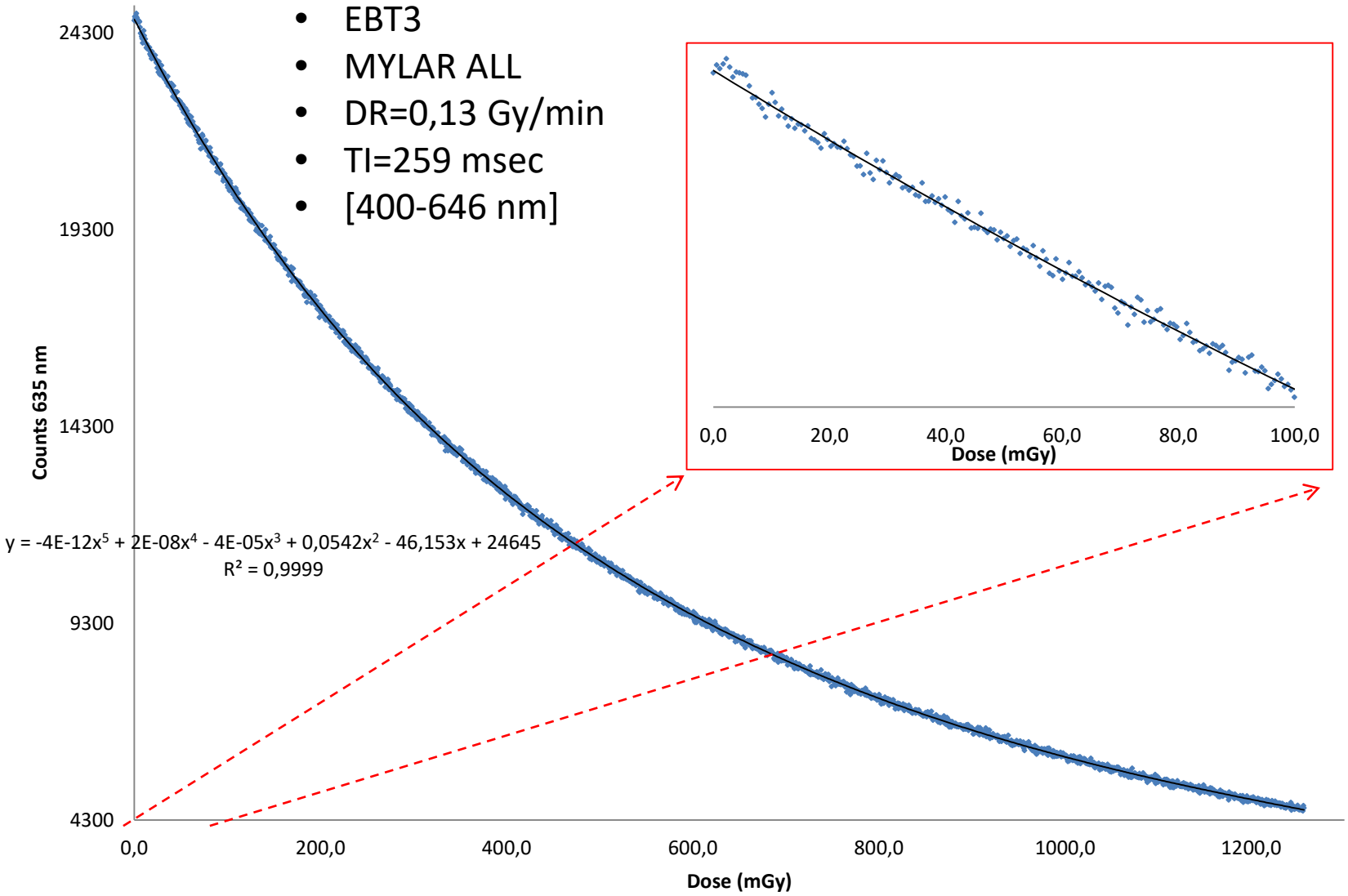


Irradiation with Gammacell 0.13 Gy/min

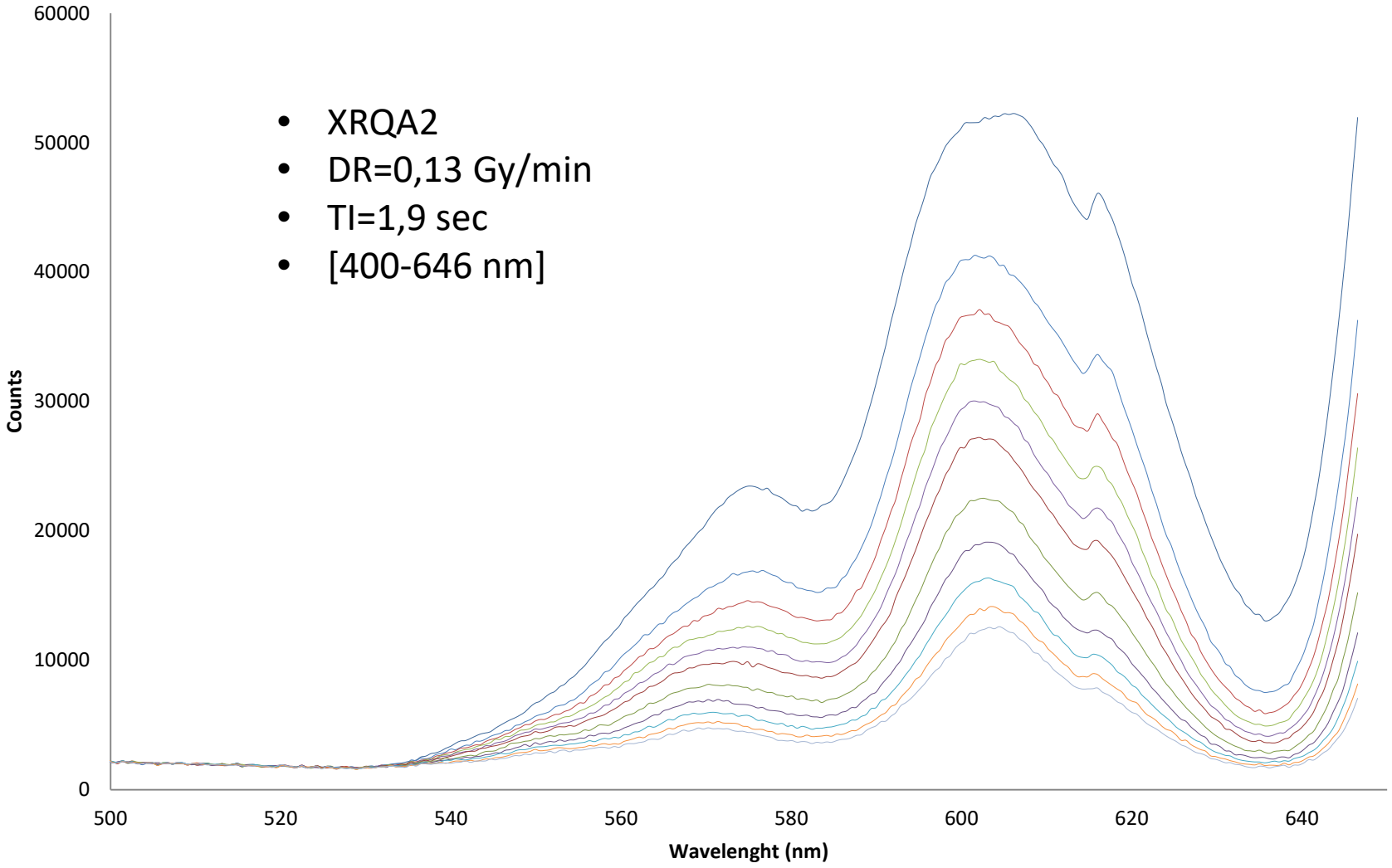
- EBT3
- MYLAR ALL
- DR=0,13 Gy/min
- TI=259 msec
- [400-646 nm]



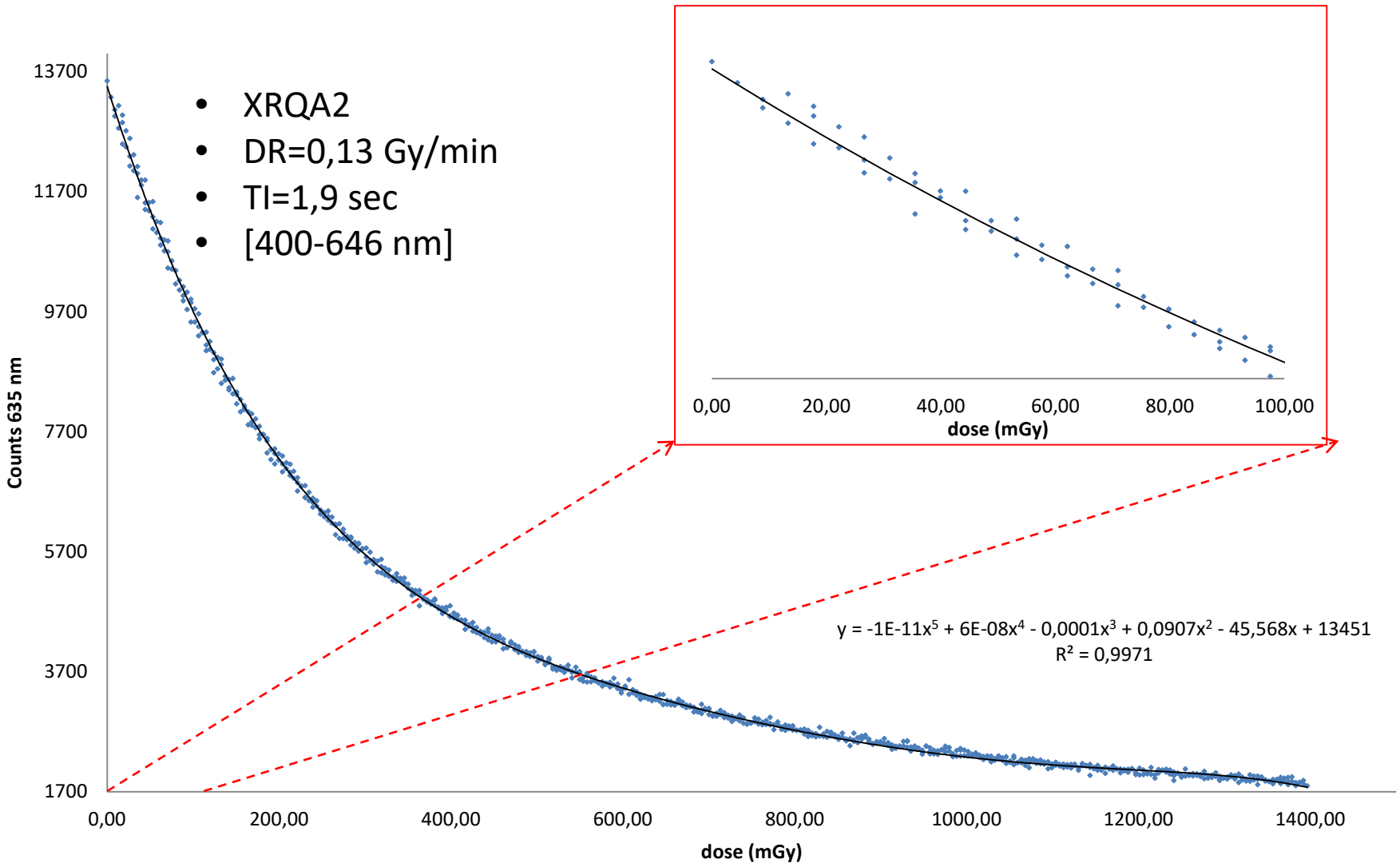
Calibration EBT3 635 nm



XR-QA2 - Irradiation Gammacell 0.13 Gy/min

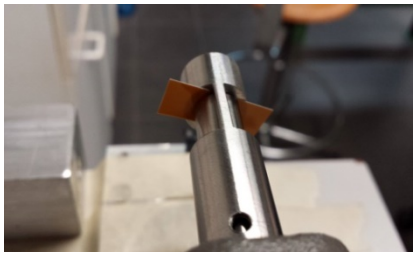


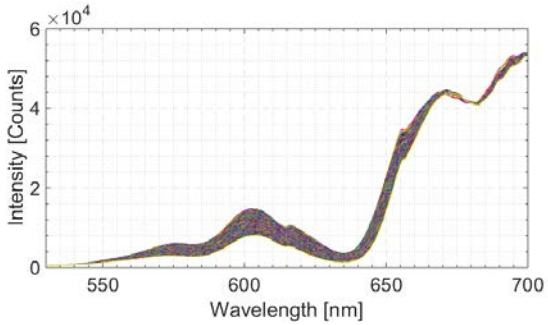
Calibration EBT3 635 nm

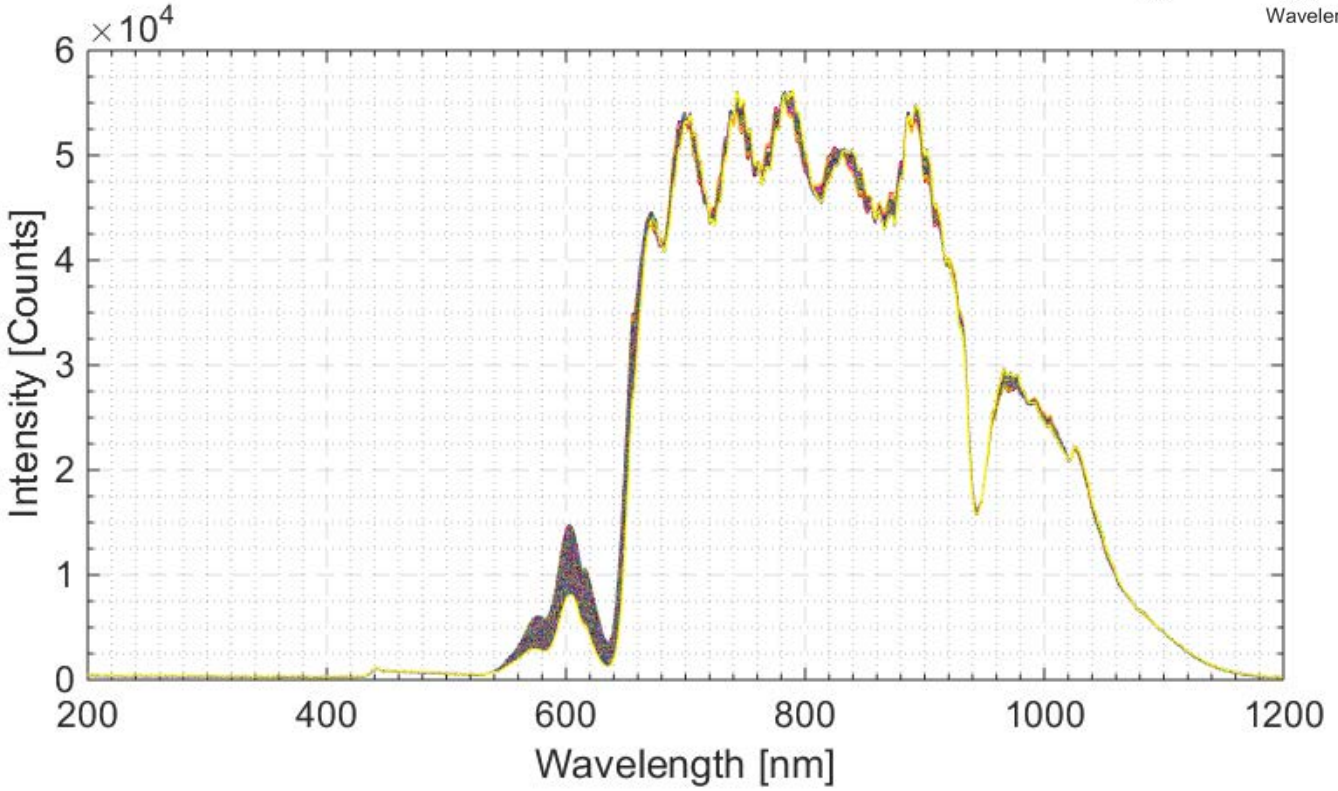


XR-QA2 Irradiation with beta source

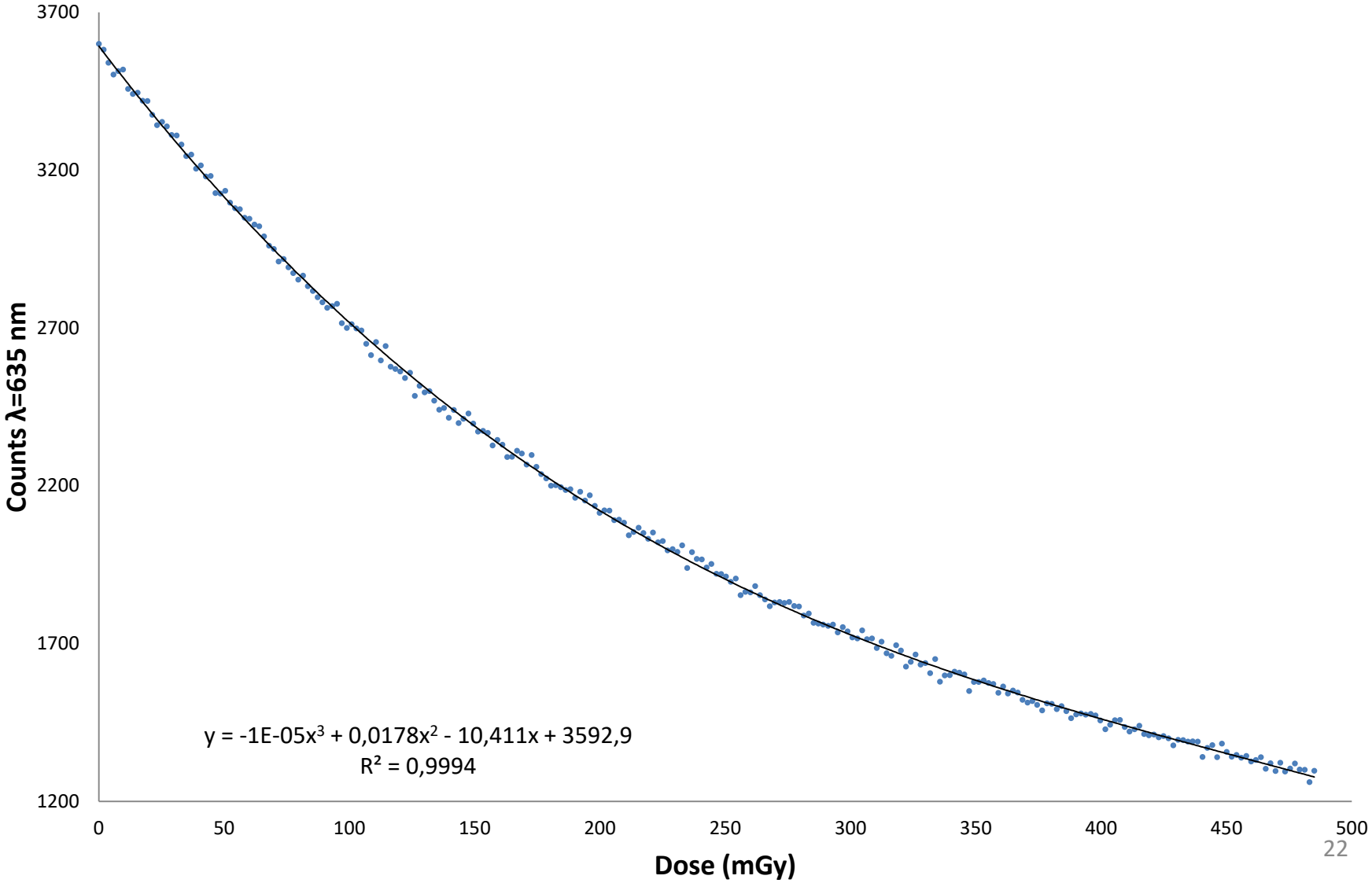
- Dose [0-500] mGy



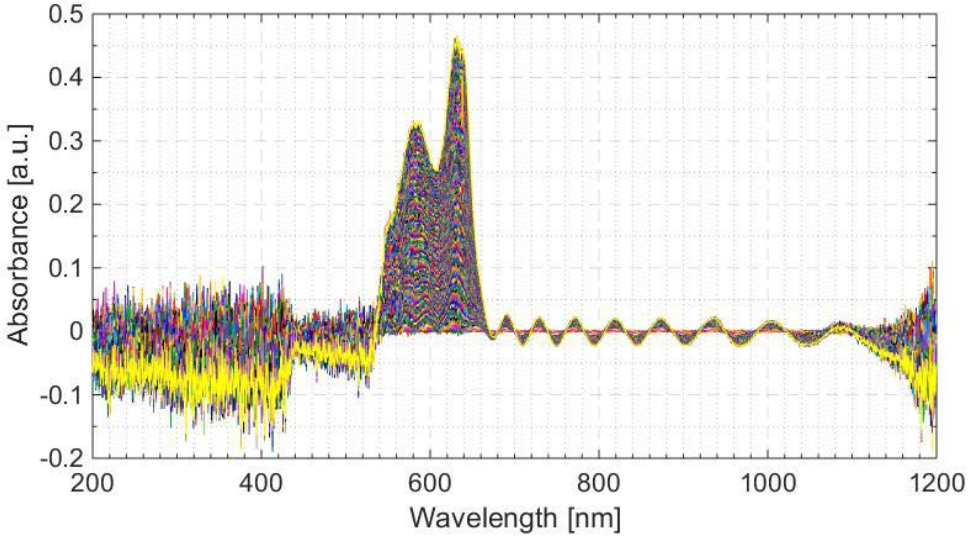


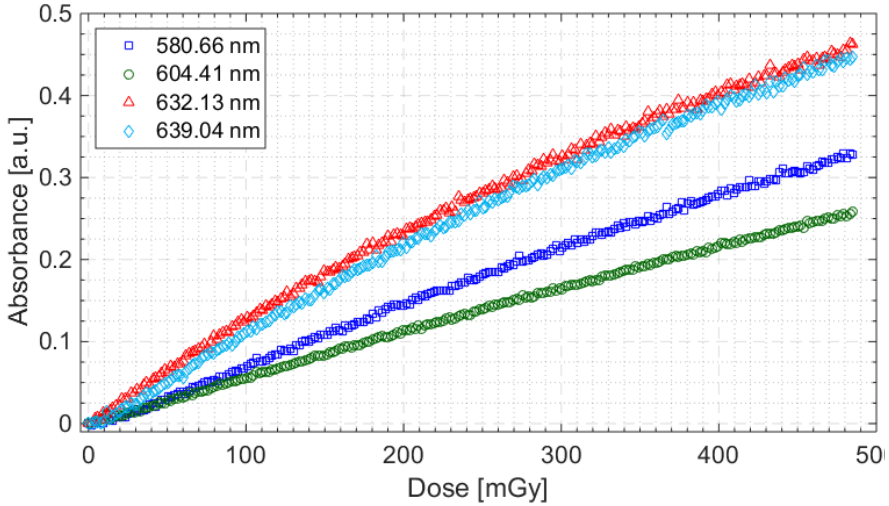


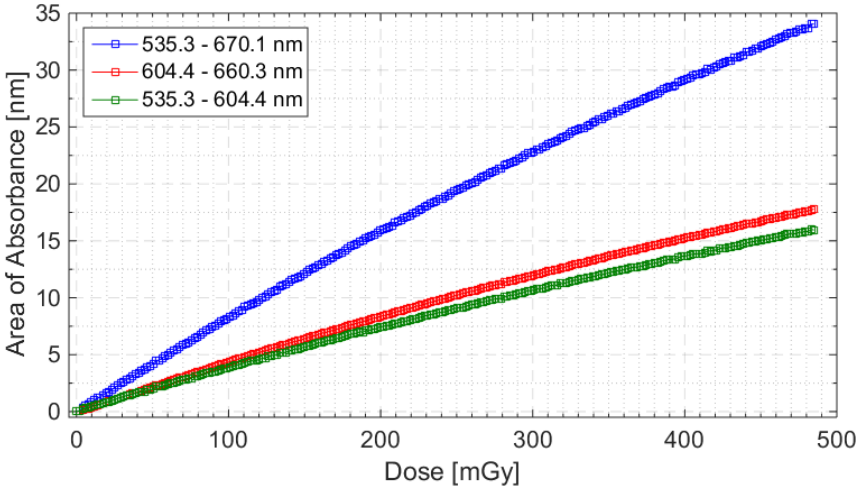
Calibration XR-QA2 635 nm



Absorbance – Area of Absorbance

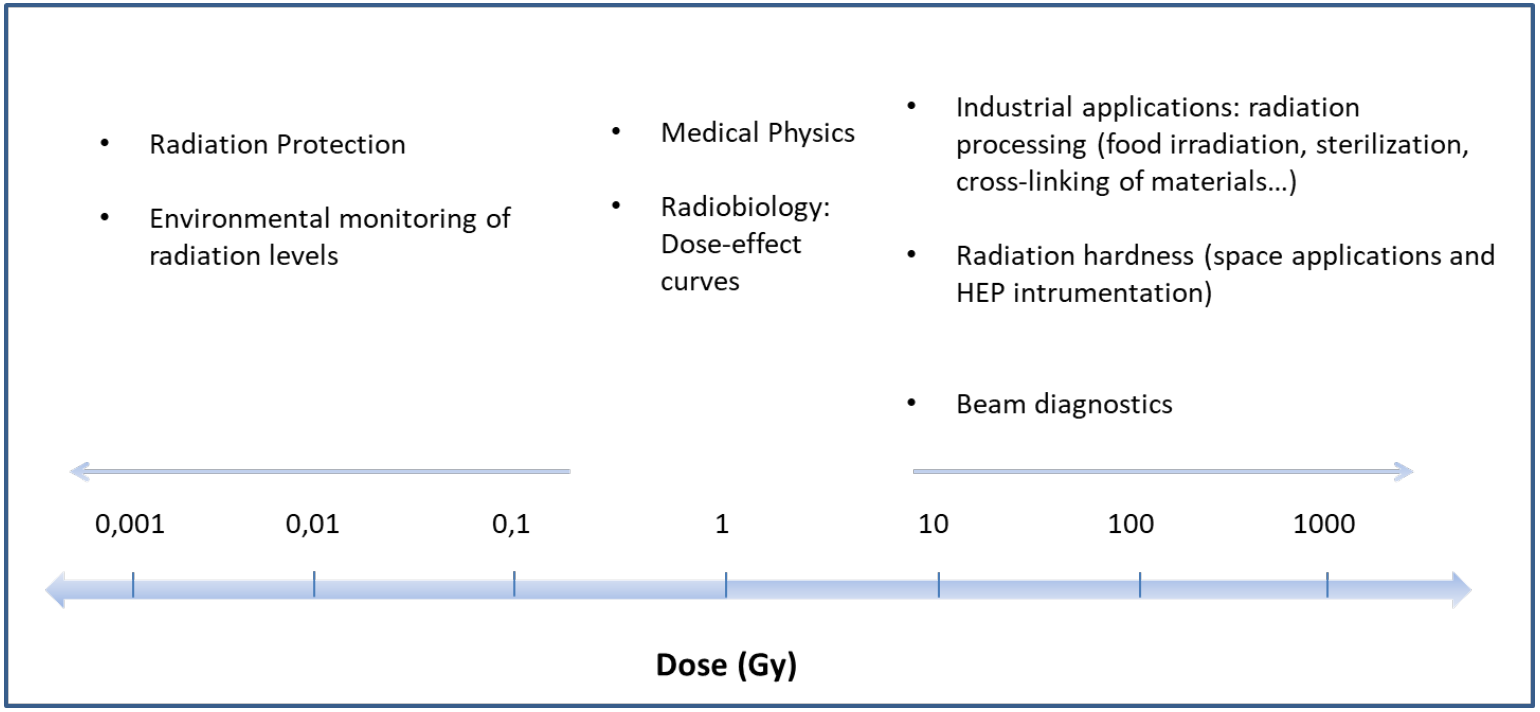






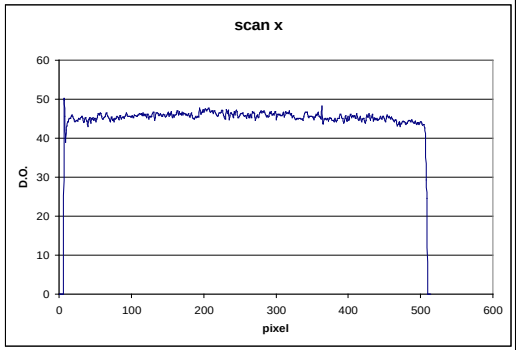
National Patent Submitted by INFN TT

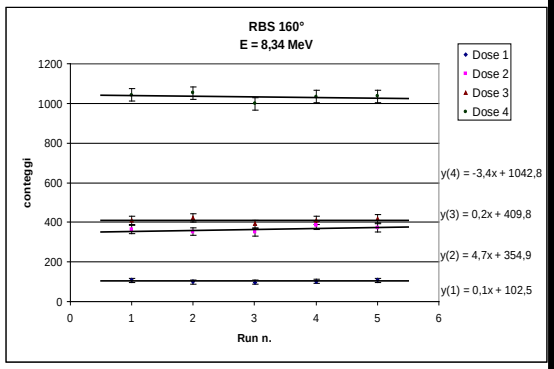
- Full characterization of new dosimetry methods
- Application in radiation physics fields



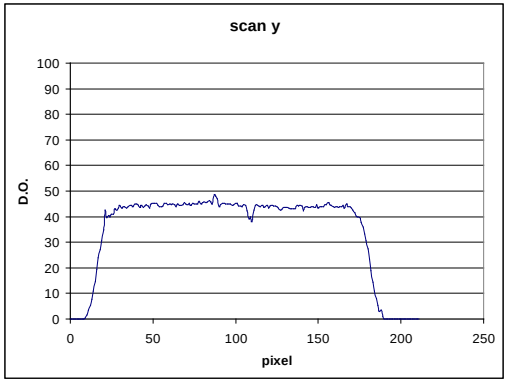
- Irradiations (alfa, beta, X, gamma, ion beams)

Beam characteristics at TTT





Ion	E MeV	$I_{analysed}$ nA	E_{max} MeV
^{1}H	6,5	100	6,5
^{2}H	6,5	10	
^{3}He	10	20	10
^{4}He	10	20	10
^{6}Li	13		13
^{7}Li	13	20	13
^{9}Be	13		16
^{10}B	13		20
^{11}B	13		20
^{12}C	16	100	20
^{13}C	16		20
^{14}N	13		16
^{16}O	16	100	23
^{19}F	19	50	23



Optical Fiber Dosimetry Working Group

List of researchers involved in this project

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Giovanni Breglio	UniNa e INFN-Na
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Francesco Fienga	UniNa e INFN-Na
Patrizio Vaiano	UniSannio

New Collaborators are welcome

Possibility of Master and PhD theses

Università degli Studi di Napoli Federico II

INFN Istituto Nazionale di Fisica Nucleare

Università degli Studi del Sannio