Characterization of the response of the microMOSFET detectors with the distance for *in vivo* dosimetry in high dose rate brachytherapy

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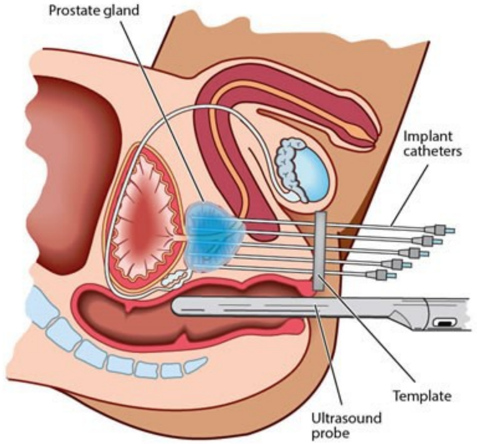
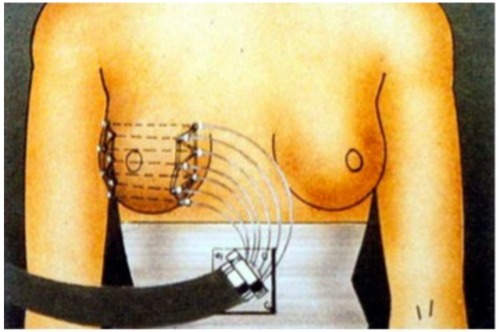
INTRODUCTION

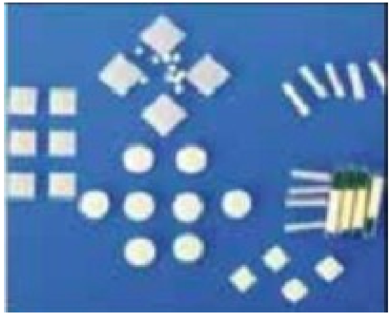
- Brachytherapy (BT) is a type of radiotherapy treatment where encapsulated radioactive sources are placed in tumor tissues.
- The healthy tissue nearby is less irradiated when compared to conventional external beam radiotherapy.
- High dose rate brachytherapy (HDRBT) is typically administered to patients with large doses per fraction.
- The consequence of a fractional error in HDRBT may be substantial.





INTRODUCTION

- *In vivo* dosimetry (IVD) provides an independent verification of the treatment delivered to patients.
- IVD is still not widely implemented in BT due to its shortcomings: i.e, detector positioning.
- Detectors used for IVD: thermoluminiscent dosimeters (TLDs), semiconductor diodes, metal-oxide-semiconductor field effect transistors (MOSFETs).



TLDs

Semiconductor detectors

MOSFETs

INTRODUCTION

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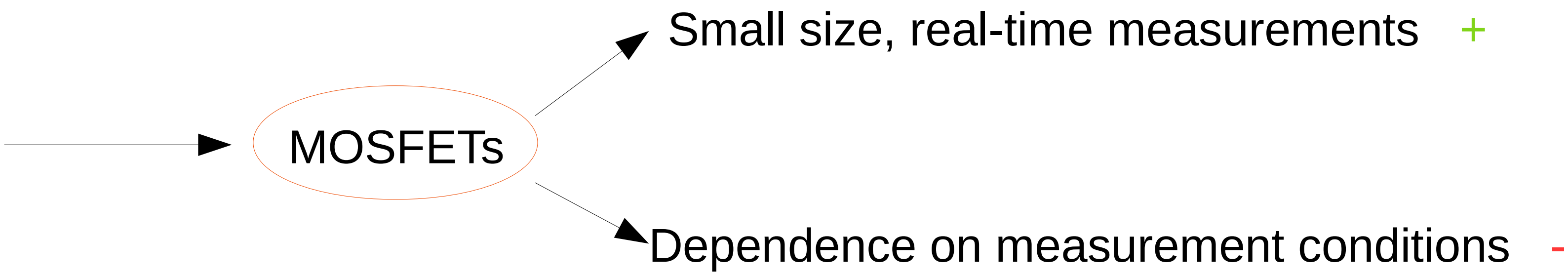


INTRODUCTION

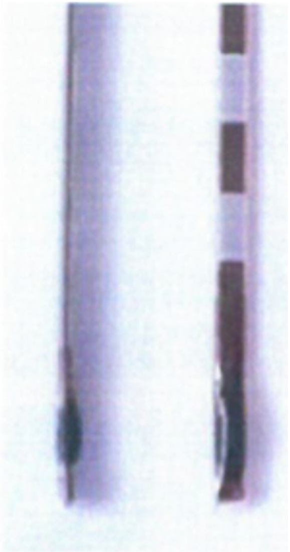
- Detector: Best Medical Canada TN-502-RDM MOSFET (microMOSFET)

AIM:

- To study the microMOSFET response with the source – detector distance
- Source: Ir-192, used for high dose rate brachytherapy (HDRBT)
- The measurements were taken in:
    - Water (energy spectrum and dose rate)
    - Air (dose rate)
- To evaluate the influence on the detector response of the needle material (plastic/steel)

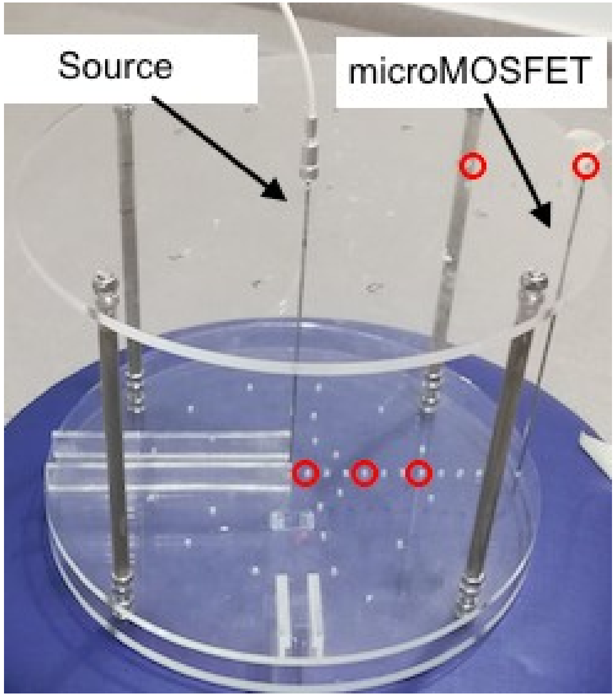
MATERIALS AND METHODS

DOSIMETRIC SYSTEM



MicroMOSFETs
1 mm x 1 mm x 3.5 mm
0.2 mm x 0.2 mm x 0.5 µm

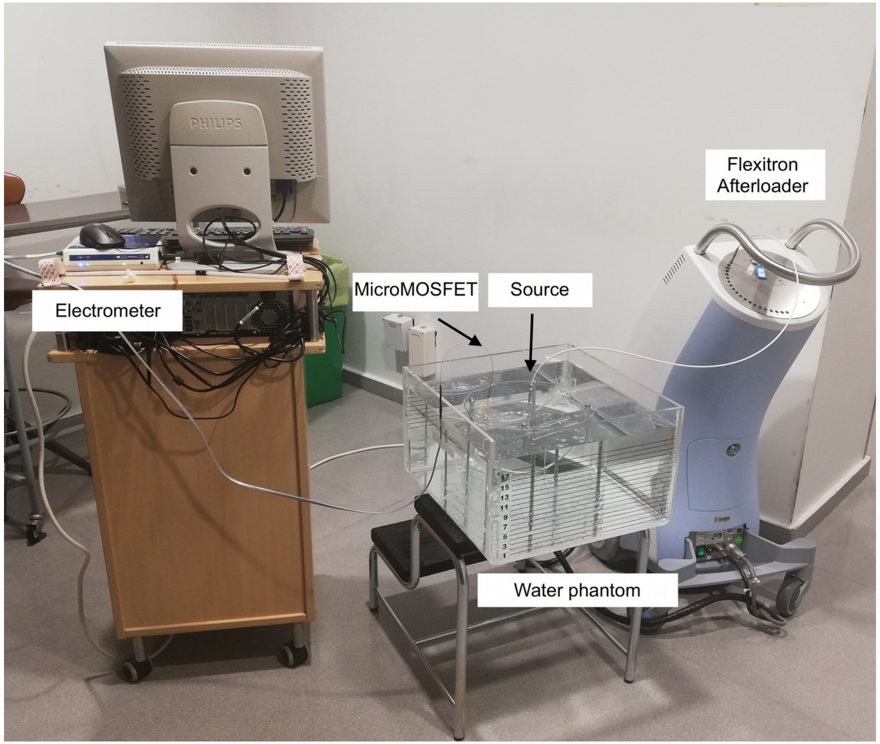
TN-RD-16 Electrometer



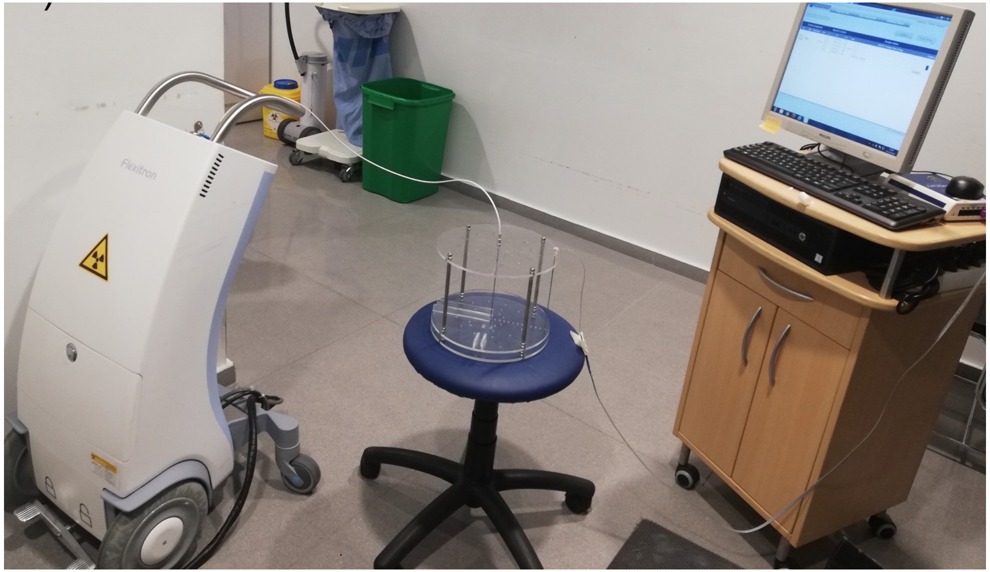
PMMA Phantom

MATERIALS AND METHODS

EXPERIMENTAL SET-UP



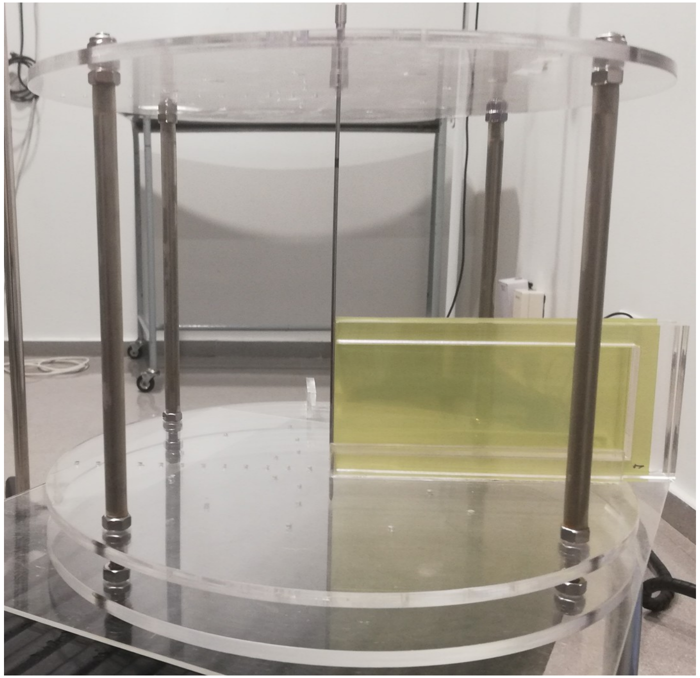
Measurements in water



Measurements in air

MATERIALS AND METHODS

- The dose distribution is calculated by the Oncentra Prostate Planning System.

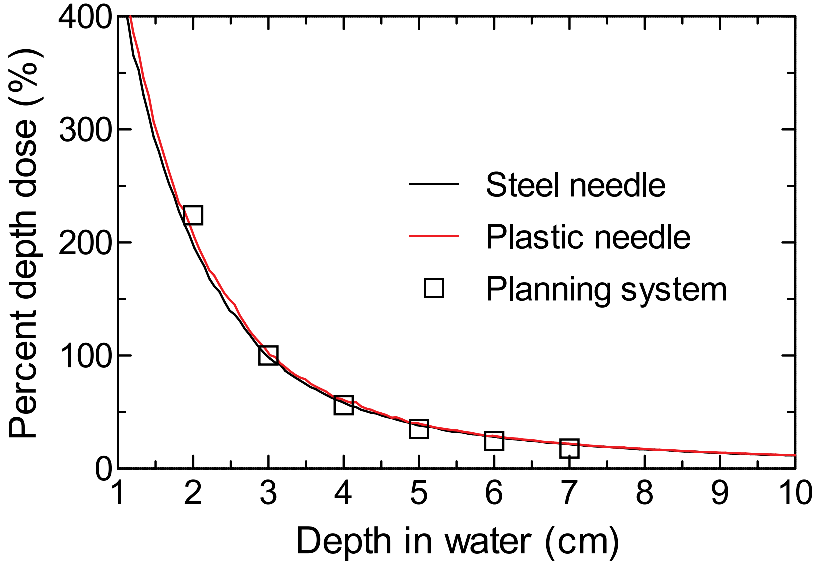


Phantom with a piece of radiochromic film

Percentage depth dose curve (PDD)

RESULTS

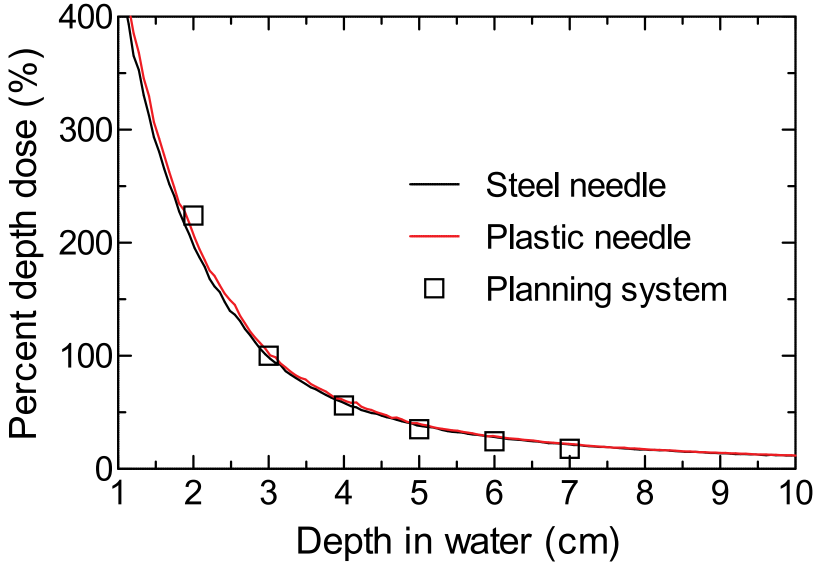
PDDs measured in water



- 3 different pieces of radiochromic film
- Water
- Steel and plastic needles
- Uncertainties up to 4%, k=1

RESULTS

PDDs measured in water

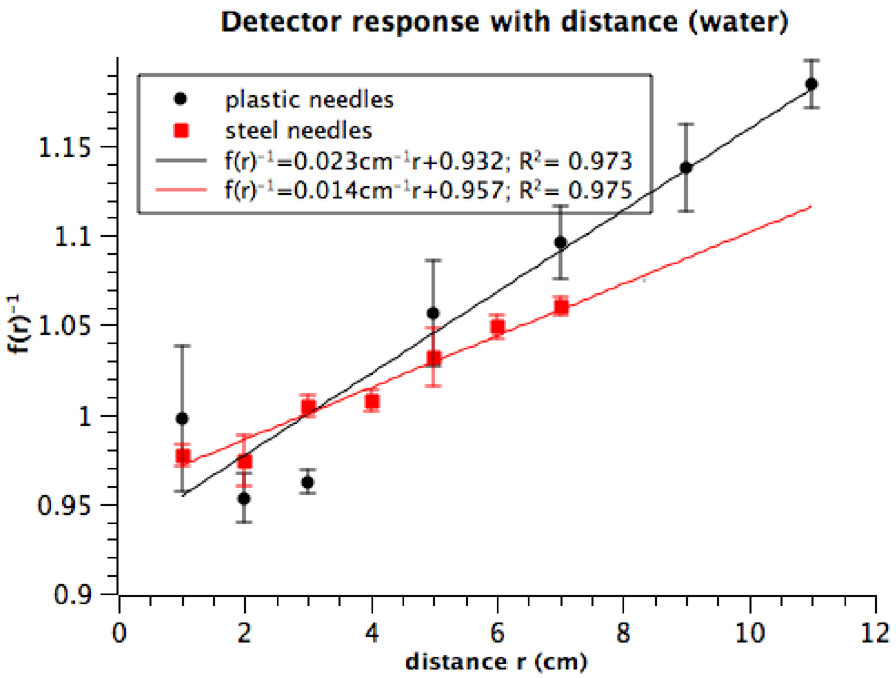


- 3 different pieces of radiochromic film
- Water
- Steel and plastic needles
- Uncertainties up to 4%, k=1

✓ Delivered dose is in agreement with the calculated one.

- PDDs with steel and plastic needles are identical.

RESULTS

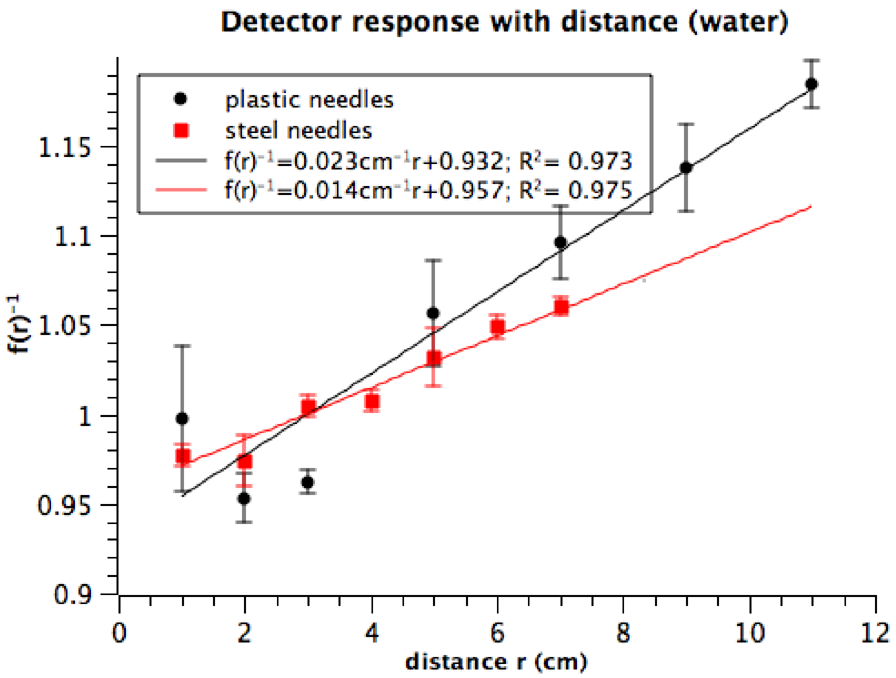


- 3 different microMOSFETs
- At each detector position the absorbed dose calculated was 1 Gy
- Water
- Plastic needles
- Uncertainties with k=1.

The results with steel needles were obtained from:

Ruiz-Arrebola S, Fabregat-Borrás R, Rodríguez E, et al. Characterization of microMOSFET detectors for in vivo dosimetry in high dose rate brachytherapy with Ir-192. Med Phys 2020; 47:2242-52

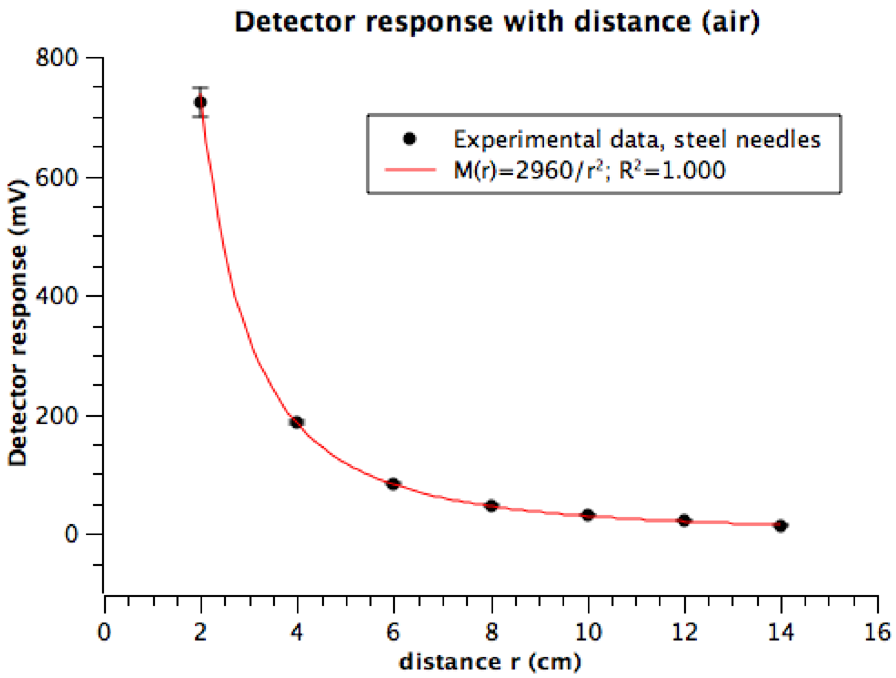
RESULTS



- Increase in the detector response of:
  - 0.023 ± 0.003/cm with plastic needles
  - 0.014 ± 0.001/cm with steel needles
- Uncertainties with plastic needles are bigger.
- The variation in the detector response might be due to changes in the energy spectrum and/or dose rate with the distance.

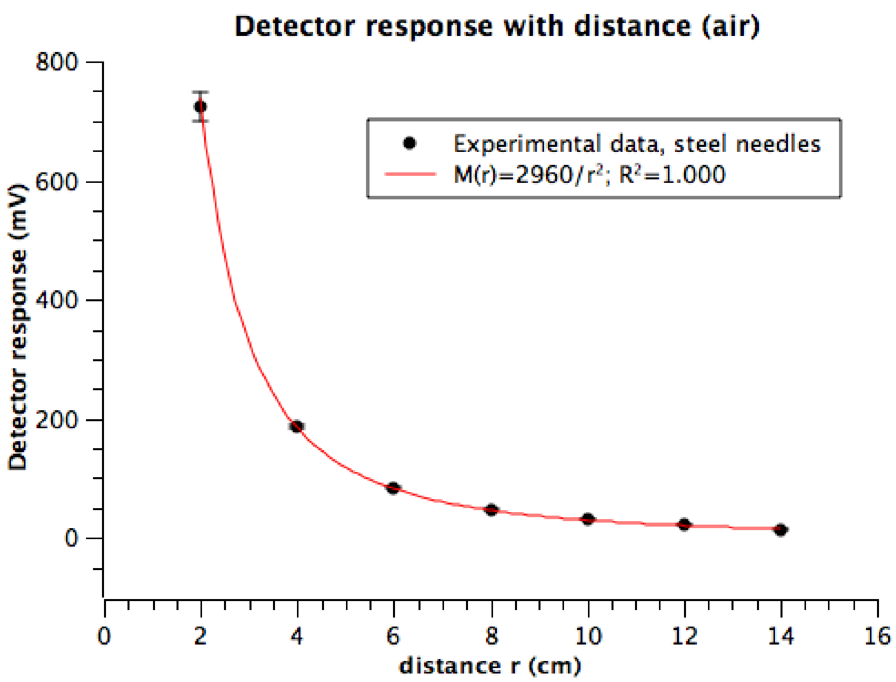
The results with steel needles were obtained from Ruiz-Arrebola et al.

RESULTS



- 3 different microMOSFETs
- The microMOSFETs were irradiated during 5 minutes at each position
- Air (only dose rate changes)
- Steel needles
- Uncertainties with k=1

RESULTS



- 3 different microMOSFETs
- The microMOSFET was irradiated during 5 minutes at each position
- Air (only dose rate changes)
- Steel needles

- Detector readings follow the inverse-square law with distance.
- There is no detector dependence with dose rate, only with energy.

CONCLUSION

- The microMOSFET response depends on the source-detector distance:
  - This is due to the change of the Ir-192 energy spectrum.
  - There is no dependence with the dose rate.

- An increase in the detector response of 0.023 ± 0.003/cm using plastic needles was measured, whereas an increase of 0.014 ± 0.001/cm with steel needles was reported.

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