A detection system to obtain 2D dose maps for Intensity Modulated Radiation Therapy (IMRT) verification

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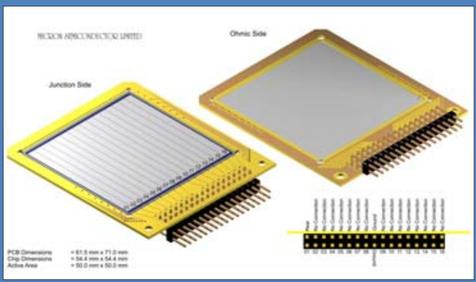
Collaboration with ATI Sistemas S. I. Company for the development of the new detector

First detector (W1-SS 500)

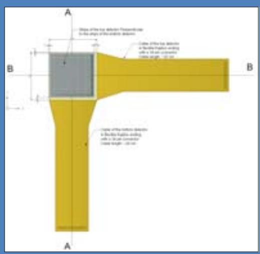
A feasibility study [(1),(2),(3)]

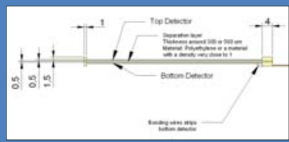


- 16 Single Sided Silicon Strip Detector (SSSSD)
- Commercial, relatively low cost detector, from Micron Semiconductor Ltd, UK
- Radiation hardness

New detector (BB7 technology)

Designed considering clinical constraints.
Developed by RADIA and the companies:
Micronsemiconductors Ltd. & ATI Sistemas S. L.





- Dual chip 32x32 SSSSD
- Introduction of a **guard ring**
- Minimum package material
- Kapton cables and package (PCB) → **Density homogeneity**
- Absence of air gaps

Why a new detector ?

Characteristics	W1(SS)-500 detector	Dual chip SSSD BB7
Nº Junction elements	16	32
Element lenght	50 mm	64 mm
Element pitch	3.1 mm	2 mm
Element width	3000.0 µm	2000.0 µm
Active Area	50x50mm²	64x64mm²
Thickness	500 µm	500 µm
Element active volume	49.5x3.0x0.5mm³	64x2x0.5 mm³
Metalization	Aluminum 0.3 µm	Aluminum 0.3 µm
Package	PCB with edge connections on one side	PCB with edge connections on one side
Structure material	FR4 (1.85 g/cm³)	Kapton (1.4 g/cm³)

- Bigger active area
- Smaller element pitch

→ Improved spatial resolution for dose maps

Mechanical system:

✓ **Angular response measurements**
✓ **2D dose measurements in the axial plane**

GOAL : to obtain 2D dose maps for complex radiotherapy planning verification

Box

Designed box to locate the detector inside the phantoms (see the right panel).

Polyethylene box
↓
Built by the same material of the phantom
↓
Same density of the phantom to avoid distortion in the signal

↓

Important issue:

the silicon detectors can not touch directly the polyethylene, but air gaps must be minimized.

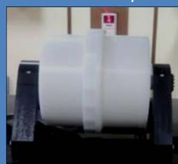
Phantoms

Phantoms used with the commercial detector (feasibility study)

Slab phantom

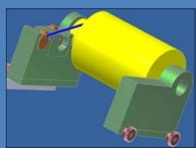
Calibration

Cylindrical phantom

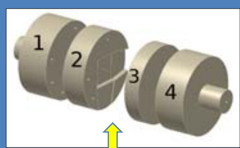


Angular response measurements & 2D dose measurements at axial plane [(3)].

Project of the cylindrical phantom for the new detector



Cylindrical rotating phantom



Housing the detector

Labview interface for remote control

Phantom rotation fully controlled by a Labview platform → Improved stability and precision of the rotation (0.1)

The measurements, with the detector inside the phantom are used to determine if the applied radiation fields will deliver the right doses when applied for tumour treatment

Calibration of the new detector

First tests performed at the Virgen Macarena Hospital

EXPERIMENTAL SETUP:

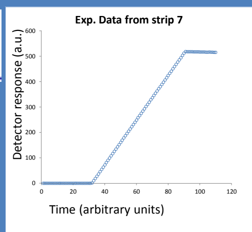
- ✓ **Siemens ONCOR Linear Accelerator (LINAC) (6 MV photon beam irradiation);**
- ✓ **Slab phantom;**
- ✓ **Detector + polyethylene box. (orthogonal irradiation);**
- ✓ **Associated electronics; (in-house development);**
- ✓ **Labview platform for data acquisition.**

The slab phantom is used :

- ✓ **For first calibration;**
- ✓ **To investigate some important parameters such as:**
  - **- Linearity of the response**
  - **- Penumbra**
  - **- Output factors**
  - **- Percentage Depth Dose (PDD)**

First measurements in hospital (new detector in slab phantom)

Response of one strip as a function of time (which is proportional to dose).



Irradiation with a 10cm x 20cm field and a source to surface distance (SSD)=100 cm. Detector is positioned as shown in the figure above.

Future challenges

- ✓ Implementation of a new detection system for IMRT
- → Online 2D dose maps in the axial plane with a spatial resolution of the order of mm
- → Benchmark this novel technique with better performance than the traditional imaging devices
- → Final product as a solution to be implemented in hospitals

Bibliography

(1) A. Bocci, M. A. Cortes-Giraldo, M. I. Gallardo, J. M. Espino, R. Arrans, M. A. G. Alvarez, Z. Abou-Haidar, J. M. Quesada, A. Perez Vega-Leal, and F. J. Perez Nieto, "Silicon strip detector for a novel 2D dosimetric method for a radiotherapy treatment verification", Nucl. Instrum. Methods Phys. Res., Sect. A. 673, 98 (2012).

(2) Z. Abou-Haidar, A.Bocci, M. A. G. Alvarez et al. "Output factor determination for dose measurements in axial and perpendicular planes usig a silicon strip detector", Phys. Rev. ST Accel. Beams 15, 042802 (2012).

(3) Z. Abou-Haidar, "A 2D Silicon Detector System for Complex Radiotherapy Treatment Verification", PhD Thesis, University of Seville, November2012.