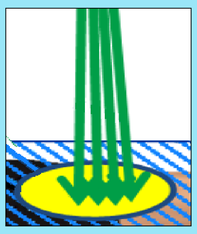
Development of a radiation resistant 3D scanner for radiotherapy treatment rooms

Samuele Cotta[1], Roland Höfling[2]

[1] OMA fellow at ViALUX GmbH, Chemnitz, Germany - email: cotta@vialux.de
[2] CEO of ViALUX GmbH, Chemnitz, Germany

Marie Curie Actions

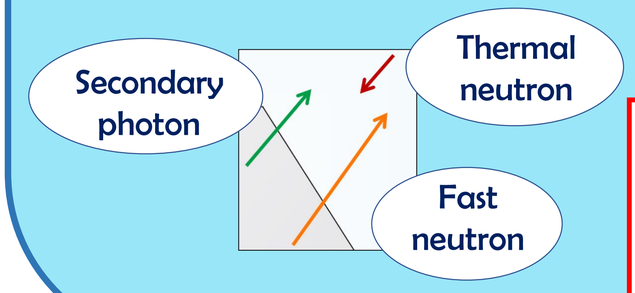
The ionizing radiations inside the treatment room



Primary photons

- Directed to the tumor
- Kill cancer cells

Secondary radiations



- Spread all around the room
- Can cause secondary tumors
- Can cause damages and/or errors in the electronic devices

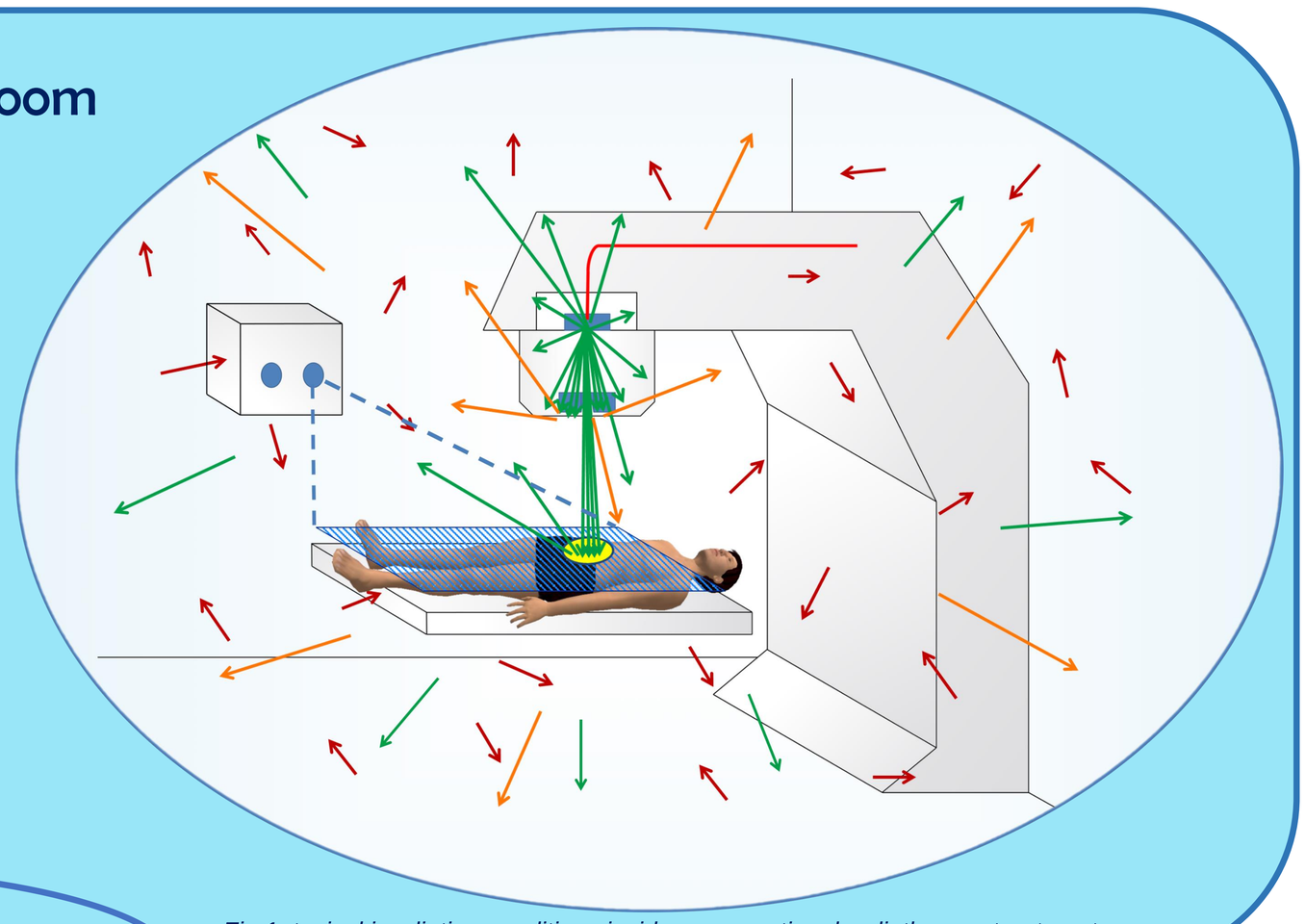


Fig.1: typical irradiation conditions inside a conventional radiotherapy treatment room.

Which?

3D scanners in radiotherapy

Tasks

- Position the patient before the therapy
- Monitor the patient position during the therapy for:
  - a) stopping the therapy if the patient is in the wrong position
  - b) treating moving tumors

Fig.2: The main components the 3D scanners made at ViALUX. (image courtesy of ViALUX GmbH)

How do they work?

1. Projection of a visible light pattern with a DLP projector
2. Image acquisition through the camera
3. Reconstruction of the patient position via software

It's a non ionizing radiation → No extra dose for the patient

Fig. 3: example of an image acquired with a 3D scanner. (image courtesy of ViALUX GmbH)

How?

Effects of ionizing radiations on electronics

1. Interaction between radiation and semiconductor devices
2. Ionization (generation of free charges)
3. Possible damages/errors due to charges deposition:

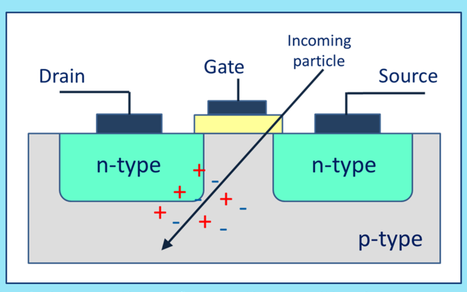


Fig.4: interaction of radiations with electronics.

Single event effects (caused by a single particle) ≠ **Long term effects** (progressive damages due to multiple interactions)

Soft errors (changes of 1 or more bit in a device memory) ≠ **Hard errors** (hardware damages)

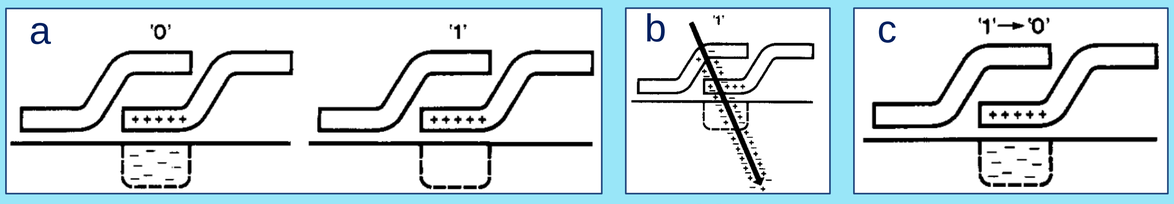


Fig.5: soft error caused by a single particle in a DRAM. [1]
The memory state of a DRAM depends on the charge of a capacitor (fig. 5a).
The free charges generated by the incoming particle (fig.5b) can cause the transition between two memory states (fig.5c).

Test the radiation hardness of the scanners

Expose the scanners to radiations to observe:

- Source of errors:
  - in which electronic components?
  - caused by which radiation?
- Soft or hard errors?
- Errors rate

Improve the radiation hardness of the scanners

Changes in the scanners design for:

- Hardware:
  - shield the device to stop radiations
  - use radiation-hardened components
- Software:
  - use algorithm to detect and correct the soft errors

Radiation resistant scanners → • No risk of inaccurate treatment • Improve patient's experience • Increase uptime → **More reliable treatments**

References: [1] T. C. May and M. H. Woods. Alpha-particle-induced soft errors in dynamic memories. IEEE Transactions on Electron Devices, 26(1):2–9, 1979.

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