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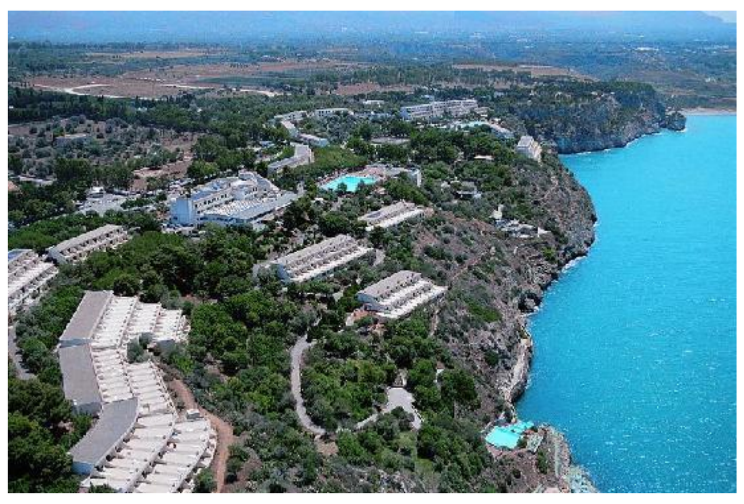
In-vivo dosimetry in prostate HDR brachytherapy with thermoluminescence detectors (TLDs)



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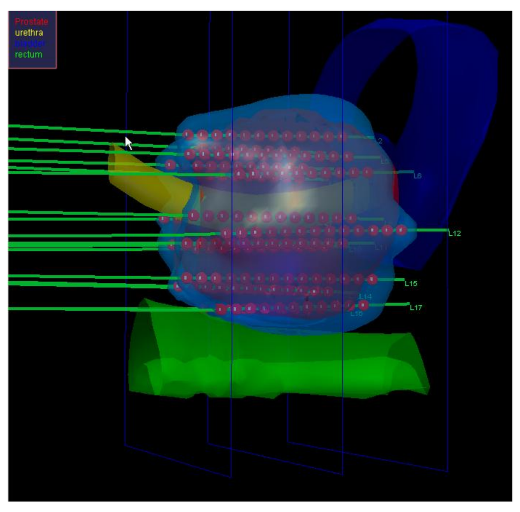
A method for performing in-vivo dosimetry inside the patient's body during brachytherapy treatments using LiF:Mg,Ti (TLD-100) has been studied and set up. A TLD calibration protocol has been defined, aimed at achieving absorbed dose values with the due precision. Some calibrated TLDs were used to perform control measurements during the brachytherapy treatments of the prostate in a few patients with the ^{192}Ir source of a Microselectron-HDR high dose rate remote afterloading device. Five TLDs were fixed to the echographic probe that remains inside the patient during the treatment. The results have been compared with those calculated by the treatment plane software (TPS) and the consistency of the technique has been verified.

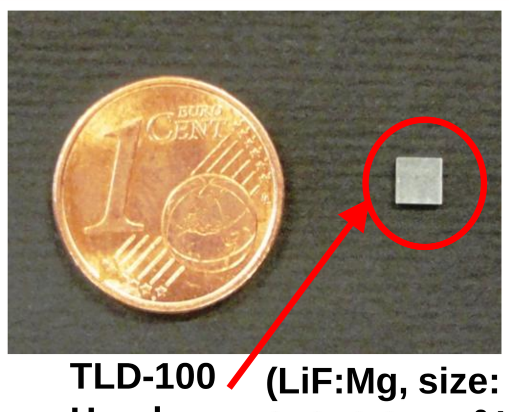
HDR brachytherapy is a conformal radiotherapy treatment in which one or more high dose rate radioactive sources are introduced inside the patient's body by little catheter or applicators. Since movement of internal organs and catheters is critical, mainly in prostate treatments, because of high dose gradients, dosimetry is very important to verify actually absorbed dose.

Graphic simulation of a brachytherapy prostate treatment.

Critical organs are indicated with different colours (prostate:red, urethra:yellow, bladder.blue, rectum:green).

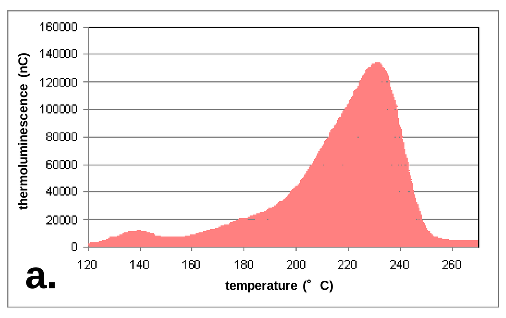


TLD-100 are lithium fluoride crystals doped with magnesium and titanium. Doping introduces new energy levels that become traps for electrons generated by incident radiation. If the dosimeters are heated, trapped electrons return in the ground state and photons are emitted. The luminescence curve vs heating temperature is called *glow curve*. The area of this curve is proportional to the absorbed dose.

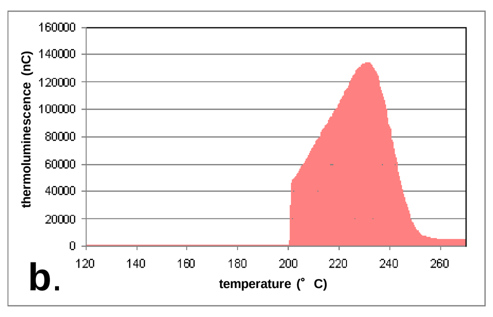


TLD-100 Harshaw (LiF:Mg, size: 3x3x0.9 mm^3)

The analysis of the dosimeters has been performed three days after irradiation to let little deep traps spontaneously empty. The glow curve obtained is shown in figure a. The <u>response chosen</u> to achieve dosimetric information is the area of the *glow curve* in the region of the principal dosimetric peak where contribution of peaks associated to little deep traps is negligible (figure b).



a.



b.

The variation with time of the gain of the photomultiplier of the analyzer has been controlled by the light source of the system and therefore measures have been corrected.

The TLD calibration protocol includes:

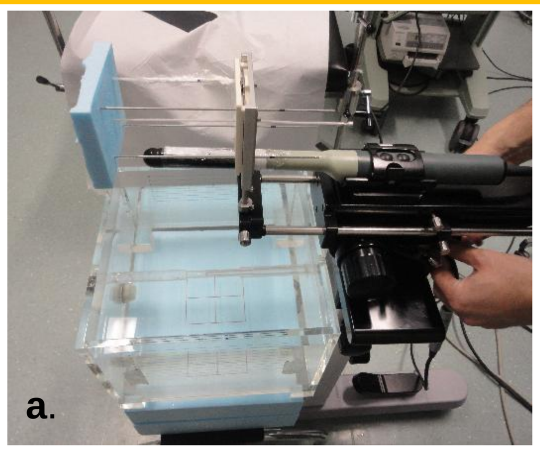
- **calculation of the <u>relative sensibility</u> of each of the 35 dosimeters used. Infact TLDs, even if they belong to the same batch, have little differences about cutting and doping. So five irradiations at known dose (0.5 Gy) with ^{60}Co source have been performed and the relative sensibility of each dosimeter has been obtained from the following equation:**

$$S_i = \frac{(mean\_response\_above\_5\_irr.)_i}{(mean\_response\_above\_35\_TLDs)}$$

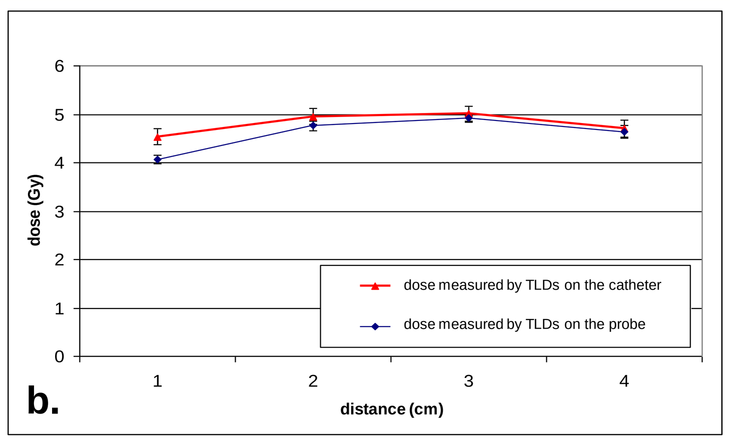
- **<u>calibration in the range of doses of interest</u> for in-vivo dosimetry (2-9 Gy). Infact calibration at 0.5 Gy is not enought because of the not linearity of the gain of the photomultiplier. So irradiations of three groups of TLDs have been performed at 3, 6 and 9 Gy and the mean response of every group has been obtained.**

The response curve got in this dose region was linear and has been utilized to evaluate the dose from the response of each dosimeter corrected by its relative sensibility factor S_i.

A study of the <u>influence of the echographic probe</u> used in the treatments on the radiation field has also been carried off. A measure in water phantom has been performed: a group of four TLDs has been fixed on the probe in the same way as for in-vivo measures and another group of four TLDs has been fixed on a catheter relatively far from the probe. The probe and the catheter have been placed at the same distance from the applicator of the ^{192}Ir source. A picture of the system (a) and the results of the measure (b) are shown: the probe influences the radiation field in a negligible way.



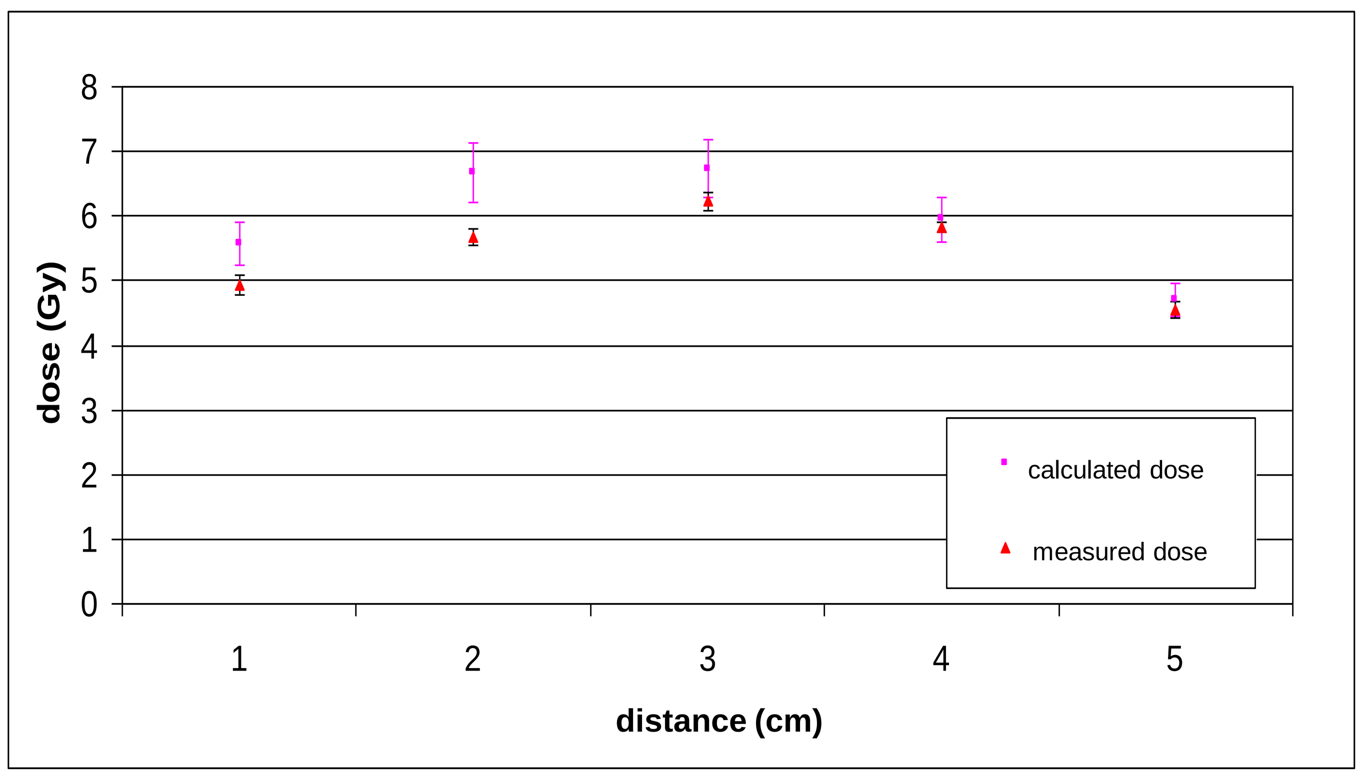
a.



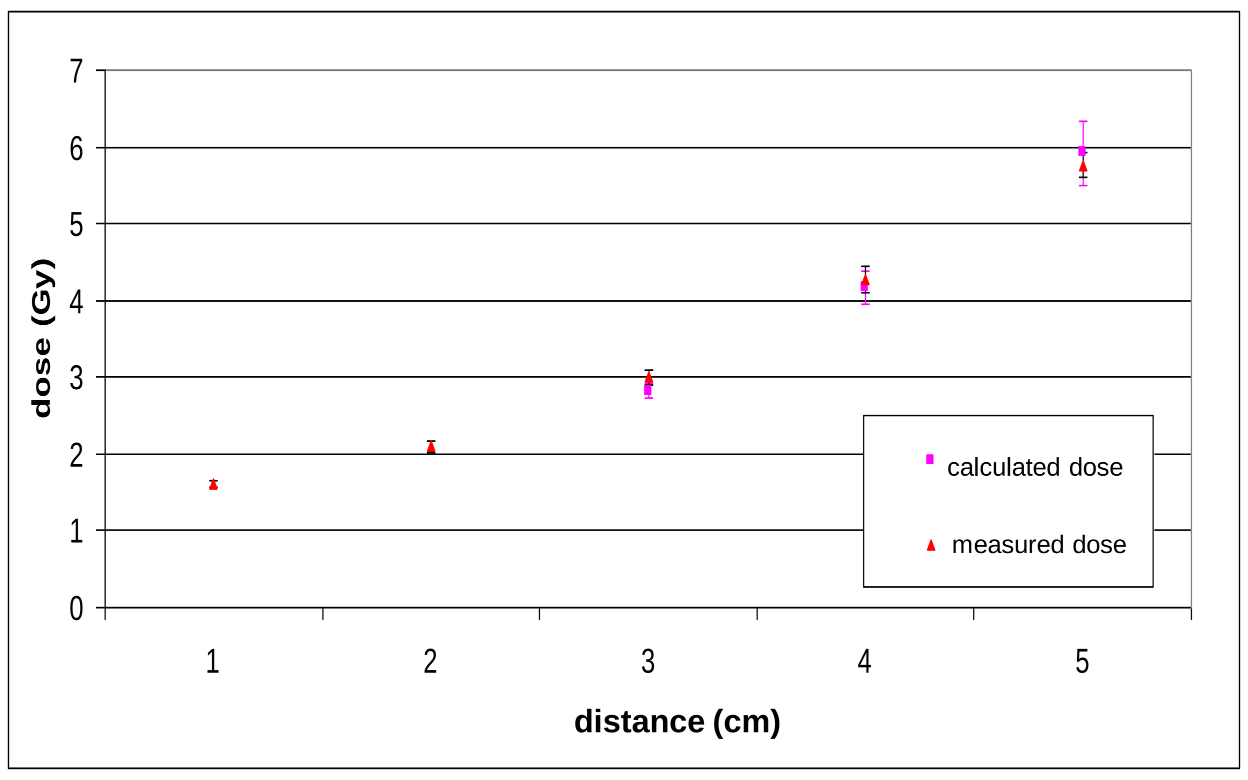
b.

Other corrections to measures have been taken into account considering the <u>dependence on incident photon energy</u> (E_{mean}= 1250 KeV for ^{60}Co and E_{mean}= 380 KeV for ^{192}Ir) and the <u>dependence on irradiation temperature</u> (T≈ 20° C in calibration while T≈ 38° C in the patient's body) reported in literature[(1)(2)].

Examples of results of in-vivo measures



The results obtained with the proposed method have been compared to those calculated by the treatment plane software (TPS): the goodness of the system has been verified.



It has also been possible to get absorbed doses in points out of the region in which they are calculable by the TPS.

1. F. M. Khan, *The physics of radiation therapy*, Lippincott Williams & Wilkins, 2003.
2. G. Kitis, S. Charalambous and J.W.N. Tuyn, 1992, *Thermoluminescent response of LiF:Mg,Ti (TLD-100) as a function of irradiation temperature for various types of radiation,* Radiation Protection Dosimetry vol. 40 no.2, 117-122.