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# An experimental study on the emitted signal linearity of $LaBr_3$:Ce single crystal scintillator excited by X-rays

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## 1. Background-Aim

Scintillators are used in indirect conversion medical imaging X-ray detectors. In addition, they are found in hybrid tomographic nuclear medicine instrumentation like SPECT/CT. Their ability to convert the absorbed ionizing radiation to optical photons leads to an increase in the detector sensitivity and in a reduction in the corresponding examinee radiation dose.

A scintillator requirement useful in planning the administered radiation exposure is a linear relation of the produced signal with regards to the incident radiation. $LaBr_3$:Ce single crystal scintillator attributes makes it a prominent candidate for use as a common detector in a hybrid SPECT/CT system.

The scope of this study is the experimental examination of $LaBr_3$:Ce linearity under X-rays exposure.

## 2. Materials & Methods I

A 10mmx10mmx10mm cubic shaped $LaBr_3$:Ce crystalline scintillator [1] was irradiated with a CMP 200DR 50kW X-ray generator. An additional 20mmAl filtration was added at the exit of its X-ray tube [2, 3].

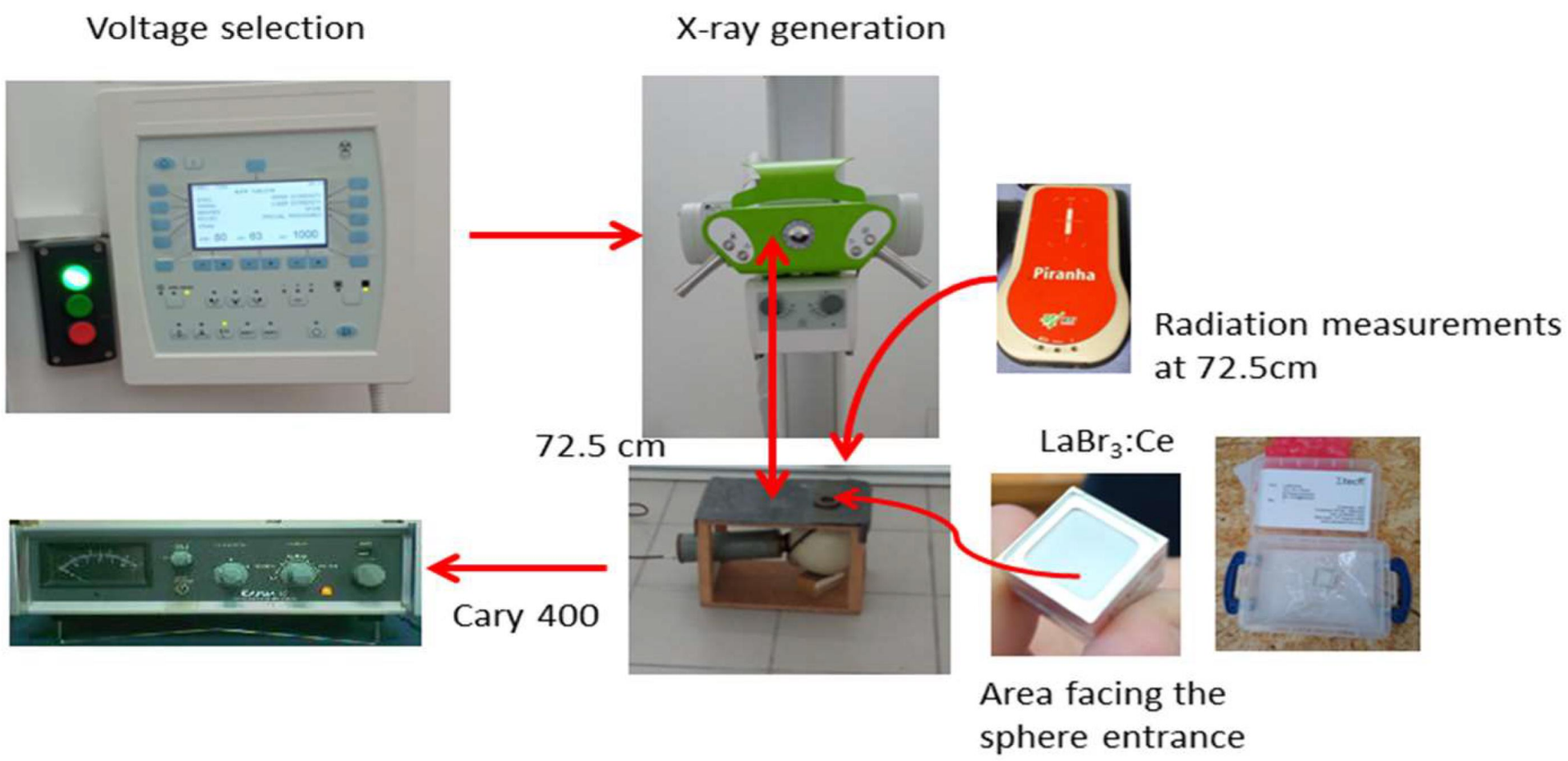
The X-ray tube voltages were from 70kV up to 140kV and the irradiation time was kept 1s. The tube load was varied from 25 to 400 mAs.

KERMA was measured with a RTI Piranha P100B multimeter [2].

The optical fluence exiting the scintillator was measured in picoampere (pA) with a Cary 400 electrometer in connection with an EMI 9798B photomultiplier tube and an integration sphere [3].

# 2. Materials & Methods II

## Experimental setup [2]



The Energy Absorption Efficiency (EAE) was calculated according to the following formula [2, 3]:

$$EAE = \frac{\int_0^{E_0} \Phi_o(E) E \left[ \frac{\mu_{en}(E)}{\rho} \middle/ \frac{\mu_{att}(E)}{\rho} \right] \left\{ 1 - e^{-[\mu_{att}/\rho](\rho T)} \right\} dE}{\int_0^{E_0} \Phi_o(E) E \, dE}$$

Where

*Φo(E)* is the X-ray spectra obtained by TASMIP online software [4]

*E* is the X-ray energy

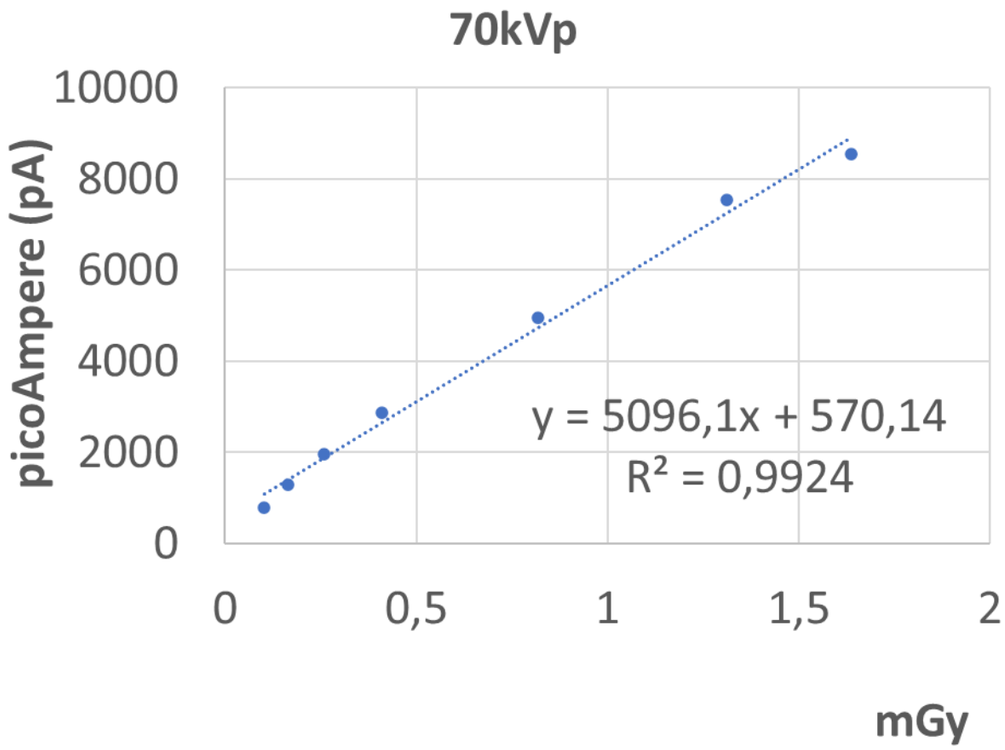
P is the density of the scintillator

T is the thickness of the scintillator

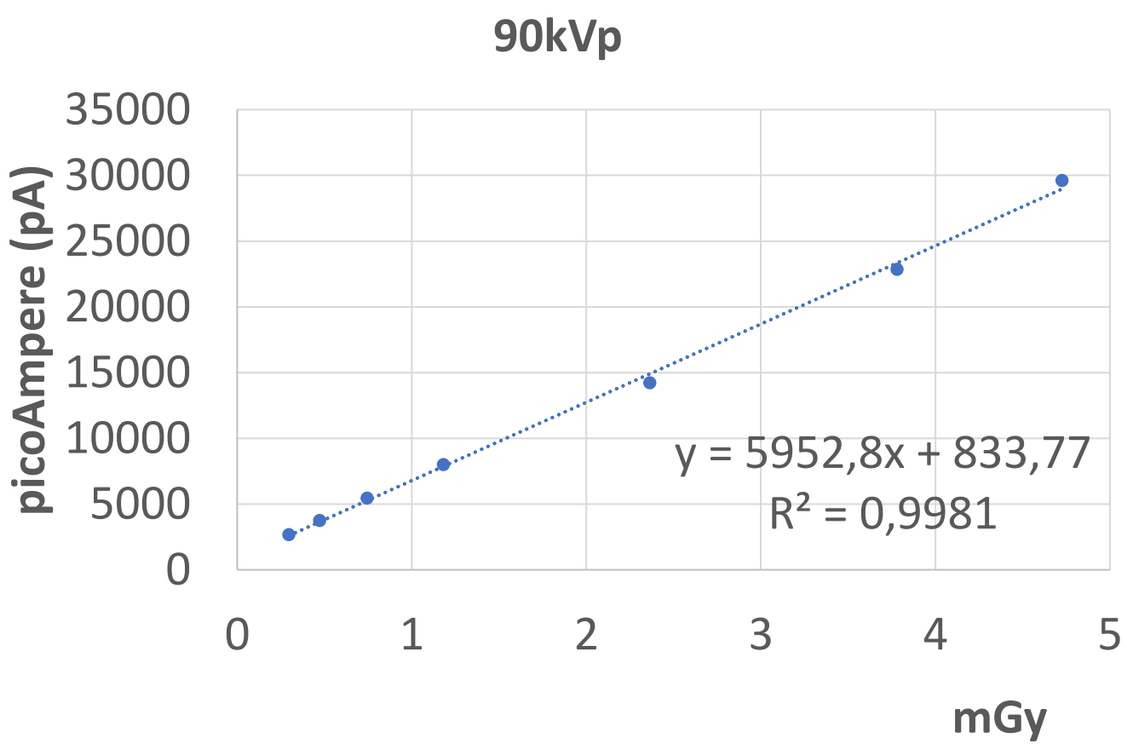
$\mu_{en}(E)/\rho$ is the mass energy absorption coefficient, obtained from XmuDat [5]

$\mu_{att}(E)/\rho$ is the mass attenuation coefficient, , obtained from XmuDat [5]

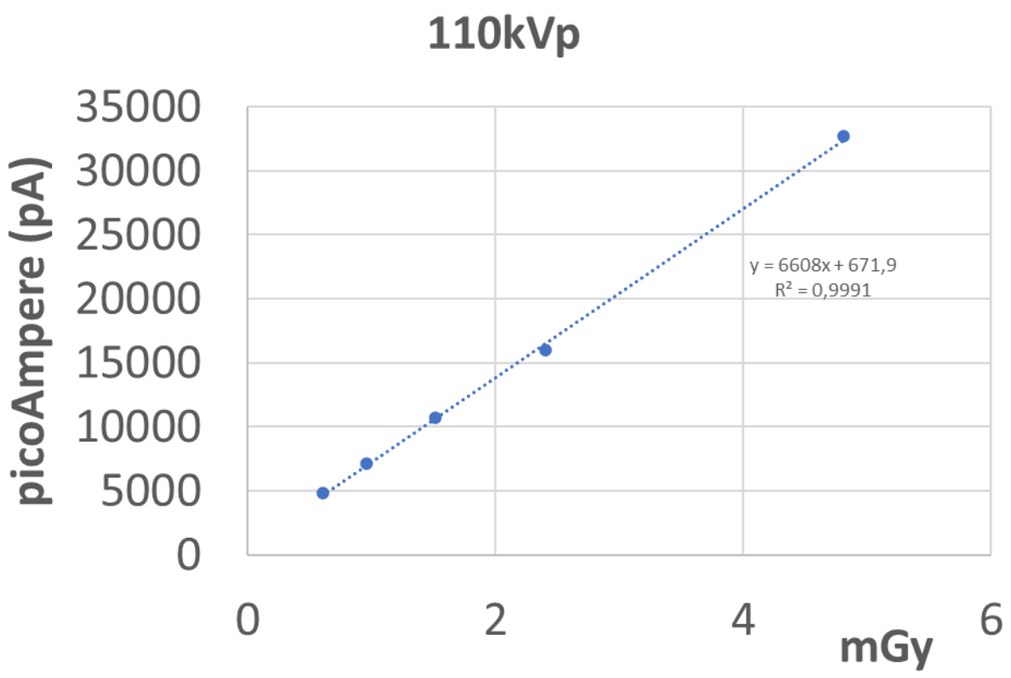
# 3. Results I-Exiting optical photon fluence for 70 kVp and 90 kVp

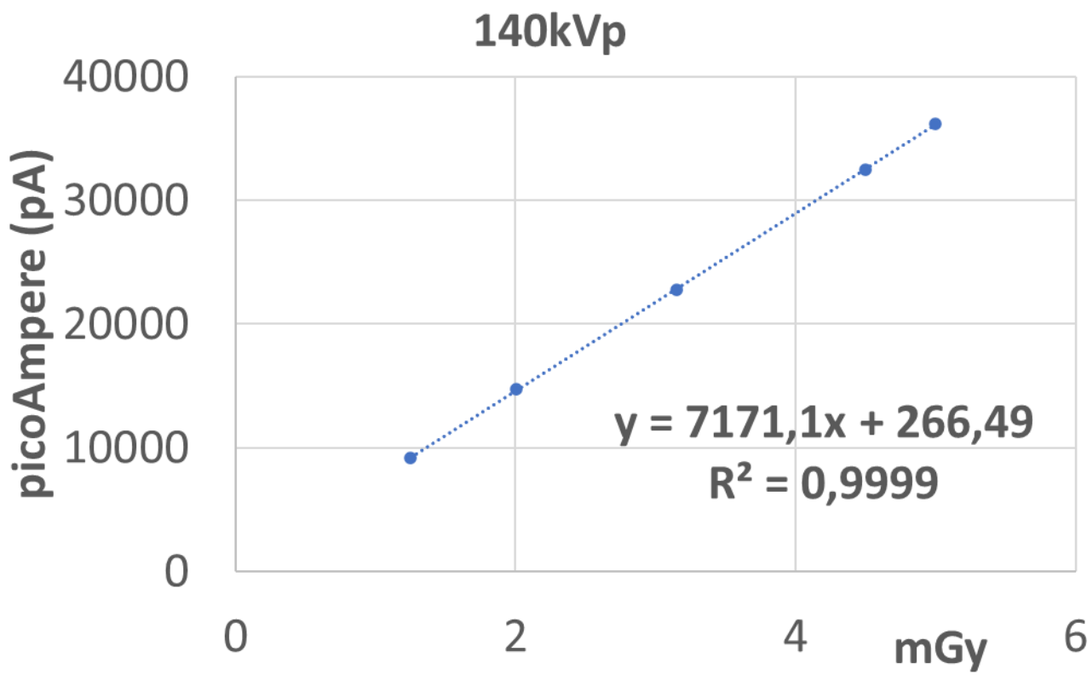



The curve $y = 5906{,}7x^{0{,}8536}$, $R^2$=0,9971 can also be fitted



# 3. Results II-Exiting optical photon fluence for 110 kVp and 140 kVp



## 3. Results III- Energy Absorption Efficiency

The Energy Absorption Efficiency (EAE) of the scintillator exhibited values from 63% to 64% for the X-ray spectra under consideration. The calculated EAE values indicate the percentage of the incident dose which contributes to the production of optical photons in the scintillator.

| kVp | EAE |
|---|---|
| 70 | 0,64 |
| 90 | 0,63 |
| 110 | 0,64 |
| 140 | 0,64 |

The incident KERMA ranged from 0,1 mGy up to 5 mGy.

The corresponding total current measured was from 778 pA up to 36202 pA.
Its relation with incident KERMA can be consider linear with $R^2$>0,99 in each case.

# 4. Conclusions

It was found that $LaBr_3$:Ce response was linear when irradiated with X-ray spectra that can be utilized in a hybrid SPECT/CT system.

A small deviation from linearity may be observed for the 70 kVp case where the power curve $y = 5906{,}7x^{0{,}8536}$, $R^2$=0,9971 can also be fitted.

The EAE exhibits values higher than 63%.

## 5. References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