Studies of the ortho-positronium lifetime for cancer diagnostics

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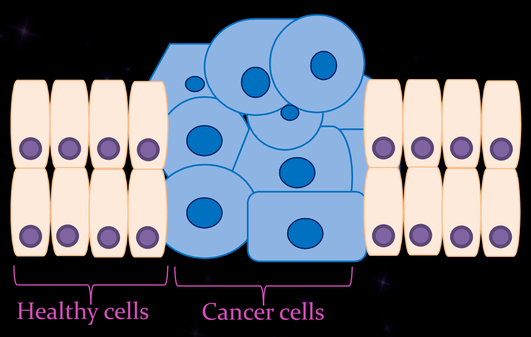
Positron Annihilation Lifetime Spectroscopy is a material testing method based on the analysis of the lifetime of positronium that depends on the structure of the material in which it was formed. Thanks to this property, we might use this method in the future for cancer diagnostic purposes. The main goal of this work was to examine the influence of environmental conditions like temperature on the properties of o-Ps formed in cancerous and healthy tissues. A series of measurements were also made to see the impact of radiotherapy and chemotherapy in order to determine relationships that can help in future research.

Introduction

Positron annihilation lifetime spectroscopy is a material testing method based on the analysis of the lifetime of positronium, which depends on the structure of the material in which it was formed. This method has potential in cancer diagnostics.

Specific changes associated with the disease state are accompanied by certain disturbances in the metabolism of certain chemical compounds. The energy in the human body is obtained mainly by the reaction of burning sugars. This metabolism is altered within tumour cells which metabolize more glucose than normal cells. To get the metabolic picture a pharmaceutical labeled with a radioisotope is injected into the patient (for example scandium).

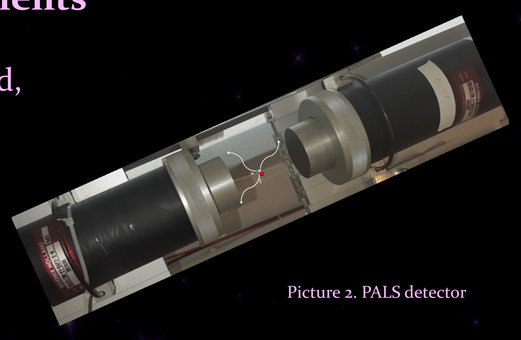


Picture 1. Healthy cells and cancer

Radioisotopes are attached to biological carrier molecules that target components of cellular metabolism and division. These isotopes undergo β+ decay emitting positrons, which may form a bound state with electron in the cell called positronium.

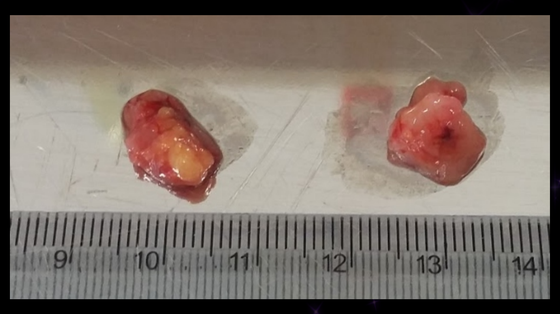
Measurements

Neon formed in the decay of sodium is excited, and emits almost immediately a gamma quantum of about 1274 keV energy.



Picture 2. PALS detector

Time of registration of this photon is used as a start signal for the lifetime measurement. The positron termalizes and may form the orhto-positronium with an electron in the material, which then decays to three photons.

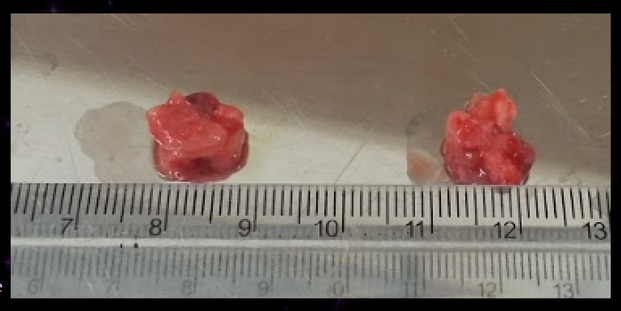


The tested samples were delivered from the University Hospital in Krakow. Both normal and cancerous tissues come from the large intestine. We already measured 24 samples.

Picture 3. Healthy colon tissue

The main goal of this work was to examine the influence of various conditions on the measured o-Ps lifetime.
For this purpose, the following studies were carried out:
- Study of the o-Ps lifetime dependence on temperature

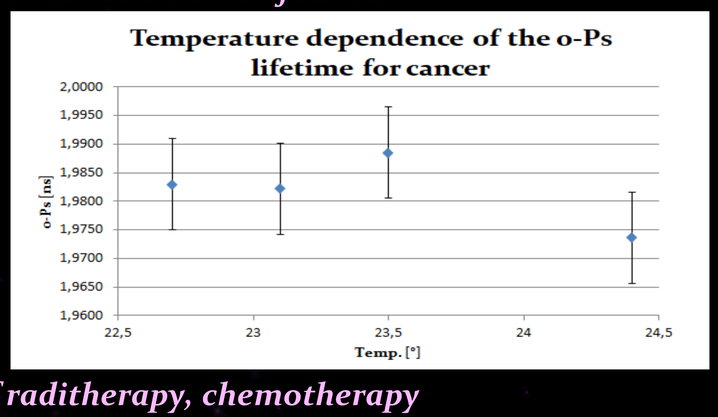
-What is the impact of radiotherapy and chemotherapy on o-Ps. The results are shown for three first patients, others are under investigation.



Picture 4. Colon cancer tissue

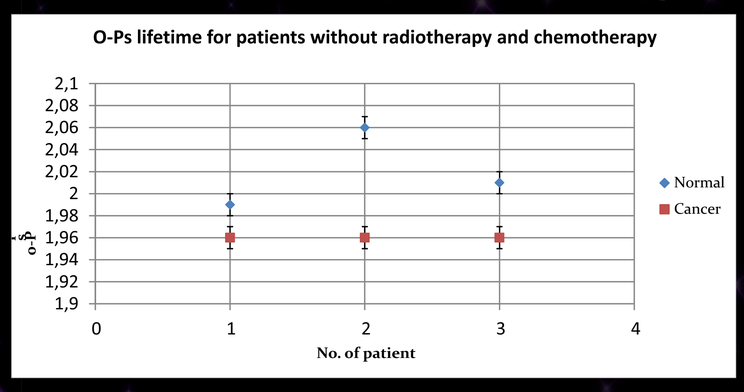
Results

Temperature dependence on o-Ps lifetime.



Graph 1. Dependence of temperature on o-Ps lifetime

The impact of raditherapy, chemotherapy



Graph 3. O-Ps lifetime for patients without radiotherapy and chemotherapy

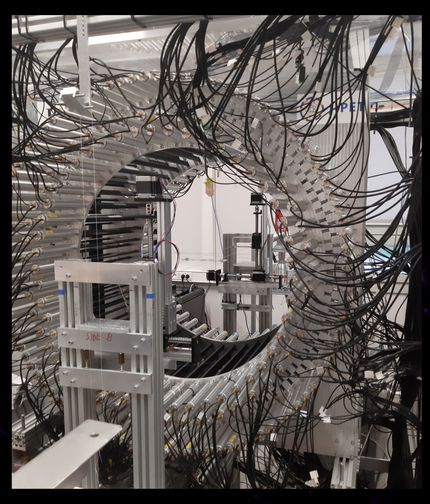
Conclusions

Base on graph 1 we know that the conditions in the laboratory are stable and the small variations in temperature did not influence our samples.

The radiotherapy and chemotherapy had an impact on tissues and the lifetime between patients are correlated. The lifetime of o-Ps for normal tissue is bigger than for cancer.

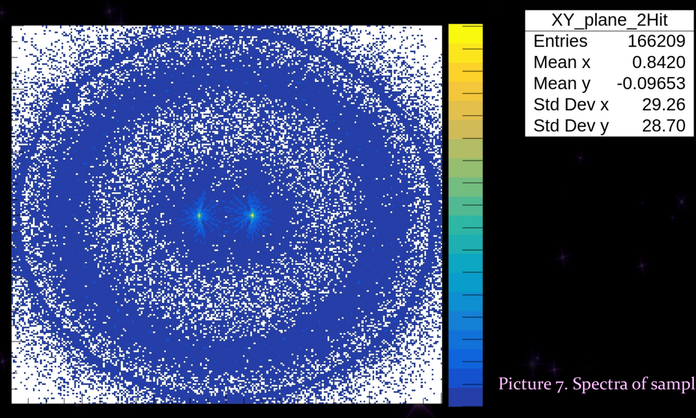
Plans for future

All the above measurements were performed on the PALS detector. Currently, there is an outgoing experiment that measures Positron Lifetime Spectroscopy in the J-PET detector. During these tests, we simultaneously study the lifetimes of cancer and living tissue. The spectrum in Picture 7 shows that we can distinguish the place of their location.



Picture 5. J-PET detector

Picture 6. Samples in J-PET detector



Picture 7. Spectra of samples in J-PET detector

Bibliography

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