Prosjektbeskrivelse master

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Project description of master theses in Nuclear physics

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Title of the project: Medical isotope production in nuclear physics: Novel pathways for the 67,64Cu theragnostic pair.

Brief summary: In this project, natZn and other monitor foils will be irradiated with neutrons to study the natZn(n,x) reaction with a special interest on measurement of cross-sections for production of 64,67Cu. 64,67Cu are two important radionuclides since they are emerging medically-valuable radionuclides. The neutrons are going to hit the targets with an energy of 16 MeV and 33 MeV, the irradiation time are approximately eight hours. The experiment will be performed in Lawrence Berkeley National Laboratory's 88-inc Cyclotron in a stacked target measurement. During the irradiation, zinc is going to be stacked together with Indium, Aluminum, Yttrium, NaCl and Zirconium which are monitor foils with well-known cross-section. This makes the result more reliable and we can therefore with a high certainty find the optimum energy that produces the isotopes in the right amount. ^{64}Cu has a half-life of 12.7 hours and decays via β+/EC which makes it suitable for imaging with PET. ^{67}Cu can be used for irradiating cancerous cells. It has a half-life of approximately 2.5 days and decays via β-. ^{64,67}Cu are theranostic pair, which means that they can be used simultaneously in both diagnostic and therapy.

Project description: The use of internal radiation has become more important over the years. A lot of development in this field has been done and there are more patients now than previously who are treated with internal radiation. The most commonly treatment with radiation is external beam therapy. Unlike internal radiation, external radiation is at risk of damaging healthy tissue when it is exposed with a significant dose of radiation. With internal radiation the radioactive drug is injected, swallowed, or placed inside the body at the area of interest and irradiates from inside. The radionuclides are attached to tracer molecules with the trait of seeking out specific cancerous cells. The exposure to healthy tissue by radiation decreases dramatically with this technique. Radionuclides that undergo beta decay emits radiation with a range that is greater than a few cells. ^{64}Cu undergoes beta+/EC decay, which means that it is a positron emitter. When a patient is diagnosed with cancer, the size and location of the tumor is key. Positron emission tomography (PET) together with computer tomography (CT) is often used to locate a tumor or metastasis in the patient. Since ^{64}Cu is a positron emitter and has a half-life of 12.7 hours it is a good candidate for imaging by PET. ^{67}Cu in other hand, decays with beta- decay and has a half-life of approximately 2.5 days. By attaching ^{67}Cu to a chelator or an antibody that is produced to find a specific antigen on the tumor, it can attach itself to the antigen and irradiate the tumor.

The advantage of these two medical isotopes is that they create a theragnostic pair; i.e they can be used simultaneously. Since they have similar properties, they can both be injected into a patient body at the same time. This makes it possible to monitor the irradiation and with certain see that the tumor gets the radiation assigned to it.

We want to measure the cross-section for natZn(n,x) reactions with neutron energies of 16 MeV and 33 MeV. The intention of this experiment is to see if we can produce these radionuclides (^{64,67}Cu) in customizable ratio for theranostic medicine.

In this experiment we will use deuterium beams with an average energy of 16 MeV and 33 MeV to irradiate a 6 mm thick Beryllium disk to produce an intense, broad-spectrum neutron flux [1], through deuterium breakup reaction. The neutron flux is then going to irradiate 0.5 mm thick targets of zinc, as well as zirconium, indium, aluminum, yttrium and NaCl monitor foils. Zinc and the monitor targets will be placed 10 cm away from the Beryllium disk to utilize the hard neutron component of the spectrum at zero degrees (w.r.t beam axis. The six different targets will be made into small "packings" using Kapton tape to tightly seal them. Loading of foil packings at various angles off beam axis will be used to measure the angle-differential neutron energy spectrum

To be able to use ^{64,67}Cu in medical application it is essential to find the right energy that will produce the best ratio of ^{64,67}Cu. But when these radionuclides are going to be used in treatment or diagnostic of cancer, we have to keep in mind that the ratio will depend on what they are going to be used for. If we purely want to do a PET scan, we want to produce more of ^{64}Cu and therefore we have to use a different energy than if we wanted to do a treatment with ^{67}Cu.

The production of ^{64,67}Cu have been done before, but this is a novel production pathway. By producing ^{64,67}Cu through ^{nat}Zn(n,x) reaction, the yield are a bit higher and you don't need high energy deuterium to make ^{64,67}Cu. Consequently, you can in theory use cyclotrons at a hospital.

References: (1)J.P. Meulders et al., Phys. Med. Biol., 1975, Vol. 20, No. 2, 235-243.
(2)A.S Voyles, et al., Nuclear Inst. and Methods in Physics Research, B, 410, 230–239