Cross-section meassurements for $^{nat}Zn(n, p)64, 67Cu$ reaction

by

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Abstract

hola

This is for me.

Acknowledgements

THANKS

Thank you grandmother, for being my safe place, even now.

Nora Irene Jensen Pettersen

DATO

Contents

Chapter 1

Introduction

"Count only the good days."

— Irene Jensen, Ahus 2017

A short introduction to nuclear medicine

Chapter 2

Theory

quote

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2.1 Background of Nuclear medicine

- why does it work
- how how we been doing nuclear medicine
- what isotopes are we currently using in clinics
- problems with is
- my work

2.2 Radioactive decay

- what is it

2.3 Decay modes

-why are these usefull for nuclear medicine (therapy and diagnstics)

2.3.1 α-decay

$$^{A}_{Z}X_{N} \rightarrow ^{A-4}_{Z-2} Y_{N-2} +^{4}_{2} \alpha_{2} + Q \tag{2.1}$$

α-decay happens in the top of the nuclear chart. Q is the amount of energy realised and are divided between the α-particle and the daughter nucleus, Y. Most α-particles have between 4-8 MeV in energy range and it will loos that energy on a very short distance in a medium. The α-particle weighs around 7.300 more than a electron and are positively charged (by two protons). Since it takes 33.85 eV to produce one electron pair due to ionization, the α-particle can produce 7.400 electron pairs within 1 μm of the decayThe α-particle can be stopped by a piece of paper, therefore, if a α-particle enters the human body it will do a lot of damage on a small area, which can be good if it seeks out a tumor. The amount of damage of the α-particles can do is dependent on its initial energy and mass. Since it has a short mean path travelled, the risk of double strand break of the DNA is relatively high.

2.3.2 β-decay

Decay by β can happen by β-, EC (see auger electrons) or $\beta+$ decay.
β-:

$$n \rightarrow p + e^- + \bar{\nu}_e \tag{2.2}$$

$\beta+$:

$$p \rightarrow n + e^+ + \nu_e \tag{2.3}$$

For therapy, e^- will travel longer in a medium than e^+ (will annihilate fast).WHY? e^- will ionize matter on its path and we want to take advantage of that. Therefore, it is β- decay we are interested in when we treat a patient. $\beta+$ decay are used in diagnostic. If we want to take a picture of the biological activity in a patient, e^+ is the source of interest for usage of PET scans, which I will discuss in section 4.1.

Compared to α particles, β particles travels a lot further and creates less ionization to the surrounding medium on its path. This is important when the biological effect matters. There are however, difference in the range of various of isotopes that undergo β decay. Short range β-particle emitters have a relatively short range, a couple of μm, in tissue that is suitable for treatment of small tumor metastasesThe β-emitters with long range in tissue can penetrate with an average of more than 2 mm and can be used to treat i.e. rheumatoid arthritis, which is an autoimmune disorder that often affect joints.

The energy of β particles are not distinct, but rather more spread out in a spectrum.

The spectrum in figure shows how the energy are divided between the electron and the anti neutrino. The electrons of beta particles will interact with the surrounding electrons by dismissing the it from its orbit and producing a ion pair or cause excitation. Since the amount of damage tissue is related to LET and β particles penetrates further in to a medium than α particles, β particles has lower LET than α does. Exposure to β results therefore in less damage.

^{90}Y is one popular long range isotope used in therapy, it has a mean range of 3.900 μm and an average energy of 935 KeV, while a widely used short range beta emitter is ^{131}I. It has a mean range of 910 μm and an average energy of 182 KeVThe energy will vary from almost zero to the maximum energy, and the average energy is approximately one third of the maximum energy. For therapy, the mean energy dependent mean and maximum range in tissue for beta emitters.

2.3.3 Electron capture, Internal convention and Auger electrons

2.3.4 γ-decay and X-rays

2.3.5 Theranostic

Chapter 3

Cu64,67

> *"- The idea that everyone is supposed to buy into stuff without questioning it, is the reason why we are 51 year old 16 year olds.*
> *- Dude, I agree. "*
>
> — Joe Rogan and Duncan Trussel

3.1 what can we do to make the nuclear medicine better?

-medical prespecctive: we wan to introduce a new theragnostic pairs to use in hospitals
- how wonderful Cu64,67 are
– properties
– papers
– better than a lot of the studff we are already using
– motivation for my work
—- can adjust ratio for 64,67 Cu by tuning the energy of the beam

3.1.1 My motivation

3.1.2 Physics motivation

- cu64,67 are amazin but now, we have not a good way for making them. tell about my way of create them
– deuterium breakup (n,-) way
– how we are doing it

Chapter 4

The experiment

quote

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4.1 The facility

- tuning of beam

4.2 Cyclotron

- k-value (descuss energies for hospital cyclotrons and what energies for Cu64,67), what is it, how does it work
- no more than a page or two (look at other theses o se how deep you should go)

4.3 Deuterium breakup prosess

- and how it is usefull for creating neutrons (brought energy spectrum that we can tune in terms of energy, inntense neutron source (makes a lot of neutrons) focused beam of neutrons
- moulders paper and other

4.4 Stack design

- photos and stuff
- monitor foils

4.4.1 Radiation

- how long time
- beam current
- beam monitor to meassure the
– plot the beam current as a function of time to justefy thet we can make the math that we do

4.4.2 Counting

- after each radiation, we removed the foils to the counting room (how long did this take?) hvor lang ti tok det fr vi begynte telle etter EOB?

4.5 Gamma spectroscopy

- Detector
– forklare hvor dypt jeg skal g inn i physics (doping, n-p junktion)
– pari production, comptopn og photoelectric effect

4.6 Gamma spectra

- deadtime, og alt det der

4.7 Calibrating

- detectror efficincy
- curves at different position

Chapter 5

Analyse

"If you ever start thinking too seriously, just remember that we are talking monkeys on an organic spaceship flying through the universe"

— Joe Rogan

5.1 Fitz peak

- Data to activity (the math). Peak counts to activity
- i - Aktivity to A_EOB
- Production physics (Analyse eller Resultater?) - how we calculate cross-sectrtion, the work with john to use the monitor data to neutron fluxes that Im going to use for calculate the cross section for my isotopes

5.1.1 Regression prosess

5.2 Priduction physics

Chapter 6

Results and dscussion

- Cross sections for all the isotopes
- experimentall data with the data that has been meassured so fare

6.1 TALYS

- tolking av resultat. Hvilke energier er best i forhold til hva vi ser?
- Verdien av dette i fremtiden?
- how can we desien target for kunne produsere mer Cu67. hvilke cyclotrons can we use for that?

Chapter 7

Summary and outlook

7.1 Future work

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