Safety with the One Curie PuBe Neutron Source

Objectives

- To become familiar with the hazards of the 1 Ci PuBe source
- Understand the neutron and gamma ray dose rates from the source
- Know how to best handle the source

Equipment

- Portable neutron detection instrument (reading in mrem/hr or similar)
- Ion Chamber
- Ruler or other measuring device

Precautions

- ☠ **DO NOT EVER TOUCH THE SOURCE**!
- ☠ The instructor is the only one who is to handle the source
- ☠ The source is only moved using the handle

Reading

- Cember, chapter 12

Background

The laboratory neutron source is a PuBe type, 1 Ci, with theoretical dose rates of:

Neutron Dose rate at 1 meter = 1.3 mrem/h
EDE on contact = 2.3×10^4 mrem/h = 23 rem/h
DDE on contact = 4.51×10^3 mrem/h = 4.51 rem/h
SDE on contact = 2.49×10^4 mrem/h = 24.9 rem/h

The half life of the Pu-239 is 2.41×10^4 y, and neutrons are emitted via an alpha neutron reaction with the Beryllium.

$$^{9}\text{Be} + {}^{4}\text{He}^{+2} \rightarrow {}^{12}\text{C} + {}^{1}\text{n}$$

Which can also be written as: $^{9}\text{Be}(\alpha,n)^{12}\text{C}$

The average neutron energy is 4 MeV (3.2 median) and the neutron yield for this 1 Ci source is 1.7×10^6 neutrons per second. The decay scheme for Pu-239 is attached.

This source is stowed in an approximately 5 gallon yellow "can" that is filled with paraffin/wax that moderates and absorbs the neutrons emitted from the source.

Procedure

In this laboratory we will be performing a radiation survey of the PuBe source to determine how closely the source matches the theoretical dose rates, as well as determining the stowed dose rate. Two different detectors will be used: Portable Neutron detector and Ion Chamber.

1. Check the instruments are properly calibrated – verify by checking sticker on instrument.
2. Check that the batteries are satisfactory for use
3. Check the instrument for physical damage
4. Turn on the portable instruments and allow to warm up.
5. Make a drawing of the area to be surveyed.
6. Check to verify that the instruments respond as expected (increasing counts near source).
7. Record background radiation levels.
8. Slowly approach the source using good survey techniques and record the readings with each instrument with the source stowed.
9. Upon completion of the stowed source survey, have the instructor expose the source and repeat the survey.

After completing the survey, determine if a radiation area is present.

Questions

1. Determine if the source/source container needs to be posted as a radiation area when stowed.
2. Determine if the source/source container needs to be posted as a radiation area when exposed.
3. Where/when would a person be required to wear dosimetry when working with this source?
4. Discuss with your instructor the limitations of the instruments used.
5. Ensure you fill out the attached survey sheets with your group and have your instructor review it.
6. What precautions will you and the other persons performing this lab need to comply with in order to safely work in this lab?

Radiation Survey Sheet – Source Stowed

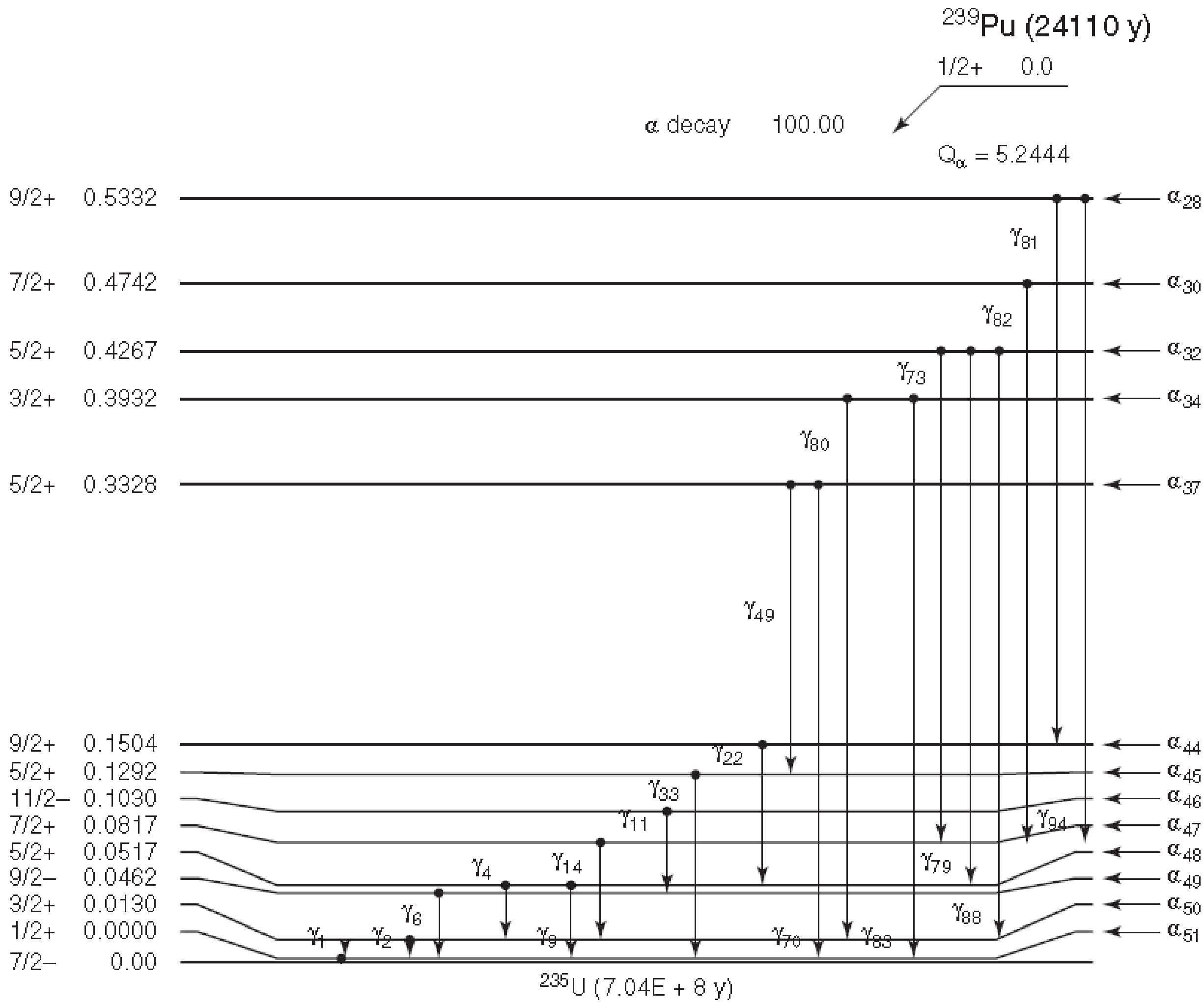
Date:
Person(s) performing the survey:
Location:
Neutron survey instrument (include serial number and date calibration due):
Ion Chamber survey instrument (include serial number and date calibration due):
Record background levels for both instruments:

Drawing of surveyed area below

Radiation Survey Sheet – Source Exposed

Date:
Person(s) performing the survey:
Location:
Neutron survey instrument (include serial number and date calibration due):
Ion Chamber survey instrument (include serial number and date calibration due):
Record background levels for both instruments:

Drawing of surveyed area below



Specific Activity		Γ		μ_{Pb}
(TBq/g)	(Ci/g)	mSv h^{-1} per MBq	mrem h^{-1} per μCi	cm^{-1}
2.3×10^{-3}	6.2×10^{-2}	8.145×10^{-6}	3.014×10^{-5}	860.3

Radiations	$y(i)$ (Bq-s)$^{-1}$	$E(i)$ (MeV)	$y(i) \times E(i)$
α 48	1.19×10^{-01}	5.106	6.10×10^{-01}
α recoil	1.19×10^{-01}	8.615×10^{-02}	1.03×10^{-02}
α 50	1.71×10^{-01}	5.144	8.80×10^{-01}
α recoil	1.71×10^{-01}	8.680×10^{-02}	1.49×10^{-02}
α 51	7.08×10^{-01}	5.157	3.65
α recoil	7.08×10^{-01}	8.701×10^{-02}	6.16×10^{-02}
γ 2	3.41×10^{-04}	1.298×10^{-02}	4.42×10^{-06}
γ 4	1.04×10^{-04}	3.866×10^{-02}	4.04×10^{-06}
ce-L, γ 4	2.35×10^{-02}	1.690×10^{-02}[a]	3.97×10^{-04}
ce-M, γ 4	6.26×10^{-03}	3.311×10^{-02}[a]	2.07×10^{-04}
γ 9	2.72×10^{-04}	5.162×10^{-02}	1.41×10^{-05}
ce-L, γ 9	6.27×10^{-02}	2.987×10^{-02}[a]	1.87×10^{-03}
ce-M, γ 9	1.73×10^{-02}	4.608×10^{-02}[a]	7.96×10^{-04}
ce-N+, γ 9	6.45×10^{-03}	5.018×10^{-02}[a]	3.24×10^{-04}
ce-L, γ 11	2.88×10^{-04}	3.507×10^{-02}[a]	1.01×10^{-05}
ce-L, γ 14	2.10×10^{-04}	4.694×10^{-02}[a]	9.83×10^{-06}
γ 22	1.46×10^{-05}	9.878×10^{-02}	1.45×10^{-06}
ce-L, γ 22	1.53×10^{-04}	7.702×10^{-02}[a]	1.18×10^{-05}
γ 33	6.31×10^{-05}	1.293×10^{-01}	8.16×10^{-06}
γ 49	5.69×10^{-06}	2.036×10^{-01}	1.16×10^{-06}
γ 70	4.94×10^{-06}	3.328×10^{-01}	1.64×10^{-06}
γ 73	5.56×10^{-06}	3.450×10^{-01}	1.92×10^{-06}
γ 79	1.55×10^{-05}	3.751×10^{-01}	5.83×10^{-06}
γ 80	3.05×10^{-06}	3.802×10^{-01}	1.16×10^{-06}
γ 81	2.59×10^{-06}	3.828×10^{-01}	9.91×10^{-07}
γ 82	2.05×10^{-06}	3.925×10^{-01}	8.05×10^{-07}
γ 83	3.48×10^{-06}	3.931×10^{-01}	1.37×10^{-06}
γ 88	1.47×10^{-05}	4.137×10^{-01}	6.07×10^{-06}
γ 94	1.89×10^{-06}	4.515×10^{-01}	8.55×10^{-07}
Kα1 X-ray	5.89×10^{-05}	9.844×10^{-02}	5.79×10^{-06}
Kα2 X-ray	3.68×10^{-05}	9.467×10^{-02}	3.48×10^{-06}
Kβ X-ray	2.85×10^{-05}	1.110×10^{-01}[b]	3.17×10^{-06}
L X-ray	4.38×10^{-02}	1.360×10^{-02}[b]	5.96×10^{-04}
Auger-L	4.38×10^{-02}	9.890×10^{-03}[b]	4.33×10^{-04}
	Listed x, γ, and $\gamma^{\pm}$ Radiations		6.62×10^{-04}
	Omitted x, γ, and $\gamma^{\pm}$ Radiations[c]		9.09×10^{-06}
	Listed β, ce, and Auger Radiations		4.06×10^{-03}
	Omitted β, ce, and Auger Radiations[c]		6.00×10^{-05}
	Listed α Radiations		5.14
	Omitted α Radiations[c]		1.18×10^{-02}
	Listed Radiations		5.14
	Omitted Radiations[c]		1.19×10^{-02}