DEVELOPMENT AND VERIFICATION OF AMERICIUM-BERYLLIUM NEUTRON SOURCE FACILITY USING MONTE CARLO N-PARTICLE CODE

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OBJECTIVE

To develop a working model of the neutron source facility at UOIT using MCNP that may be used to

- Aid researchers during the design of experiments, reduce exposure to radiation (ALARA), and improve security
- Simulate the addition of a 40 mCi Am-Be neutron source
- Determine if the additional source will increase the dose rates in occupied spaces around the facility above 2.5 µSv/hr, according to UOIT storage limit

INTRODUCTION

- The neutron source facility at UOIT houses 3 x 40 mCi Am-Be neutron sources
- Each source is suspended in one of nine aluminum tubes and are able to be raised or lowered
- Storage configuration: sources nested inside two acrylic boxes separated by 24cm of light water
- Irradiation configuration: sources stand almost 2m above the floor within the aluminum tubing
- An exclusion cage was strategically stationed around the facility so that any researcher outside of the cage would be exposed to a dose rate lower than 2.5 µSv/hr
- FESNS has obtained a fourth Am-Be source to be added to the facility inventory
- To determine if the cage ought to be widened to accommodate the source an MCNP model has been developed to verify dose levels remain below 2.5 µSv/hr

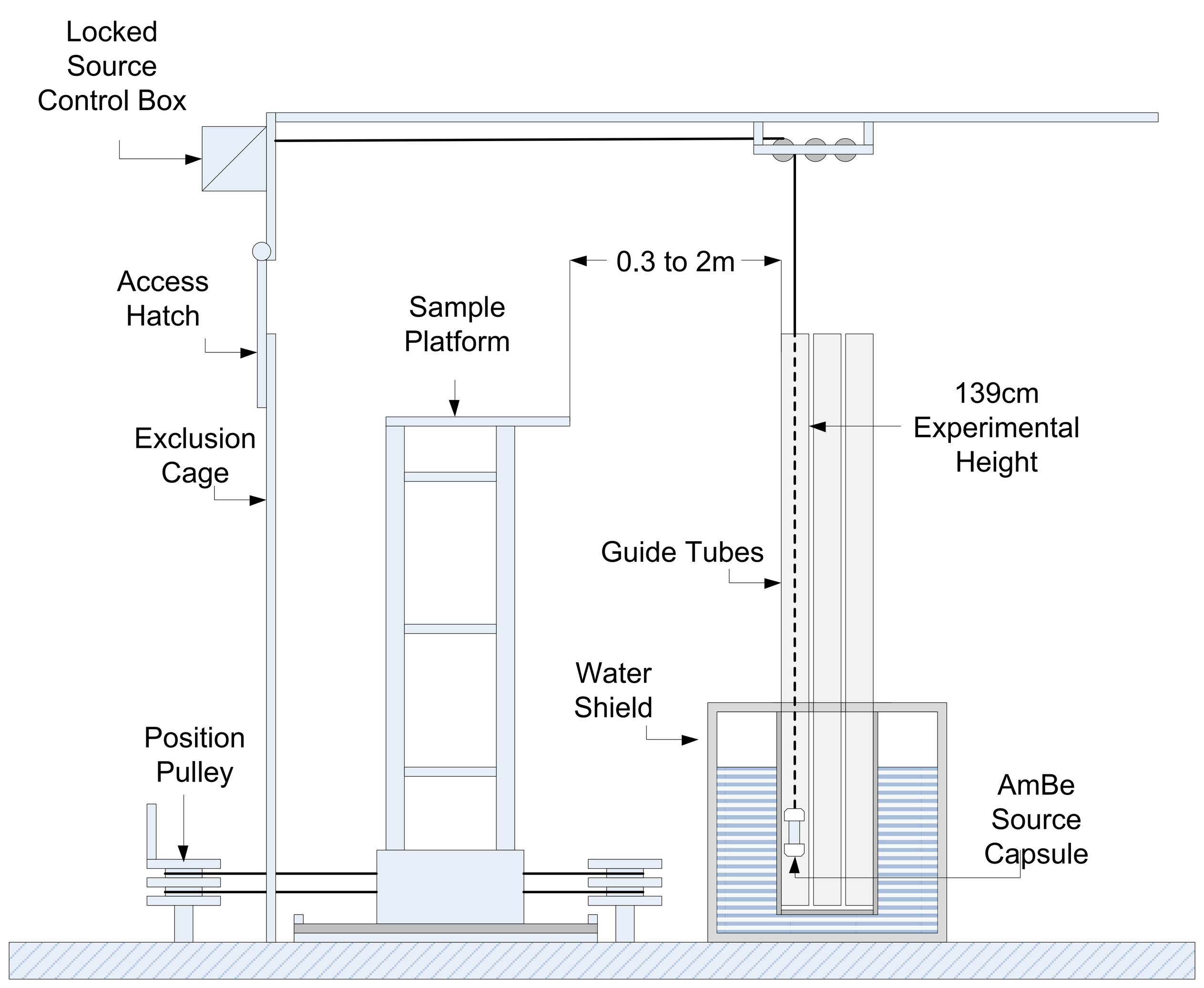

Figure 1. Side view of neutron source facility [1]

METHOD

- A geometric model of the room with AmBe source storage tank, aluminum tubes, and detectors was built in MCNP

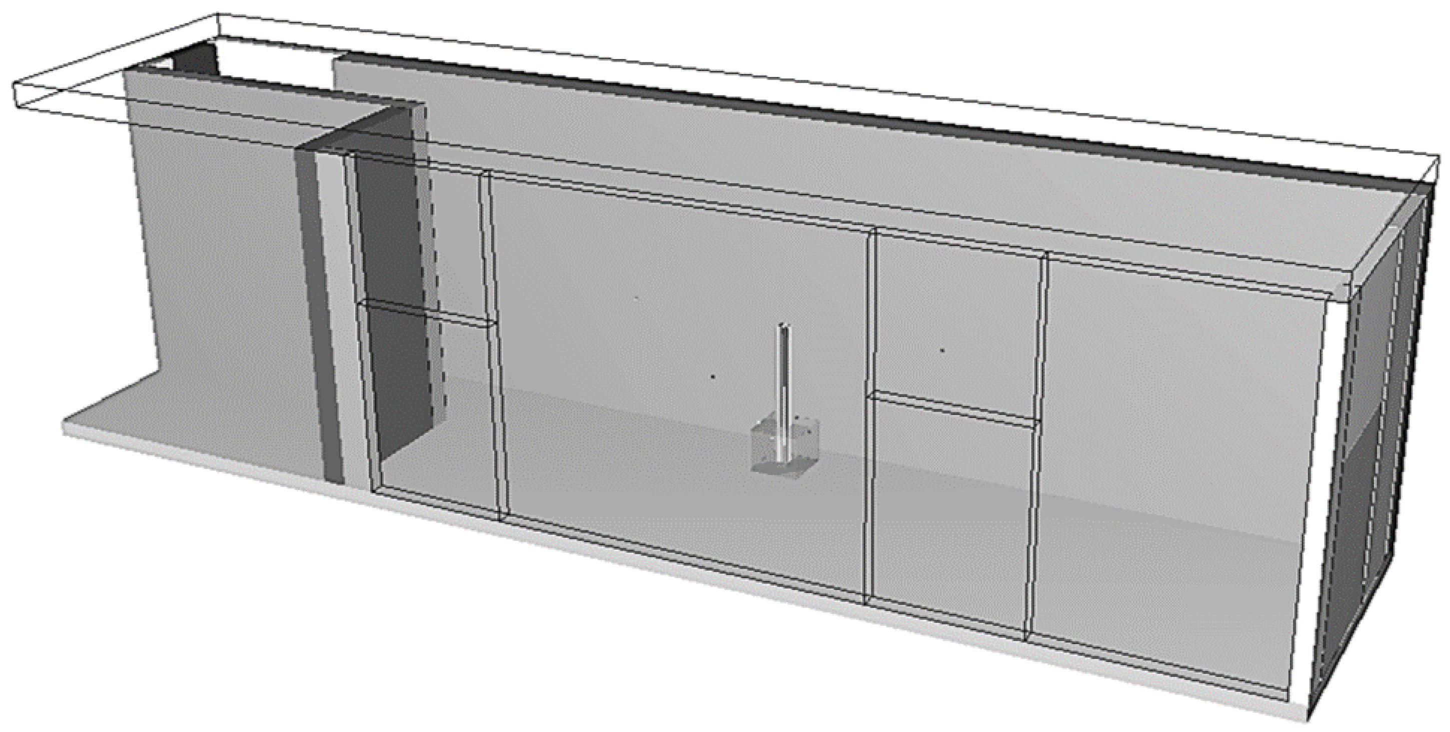

Figure 2. MCNP generated plot of facility

- MCNP results were tallied at the same location as measured using survey meter around the Am-Be source storage tank, marked A through G

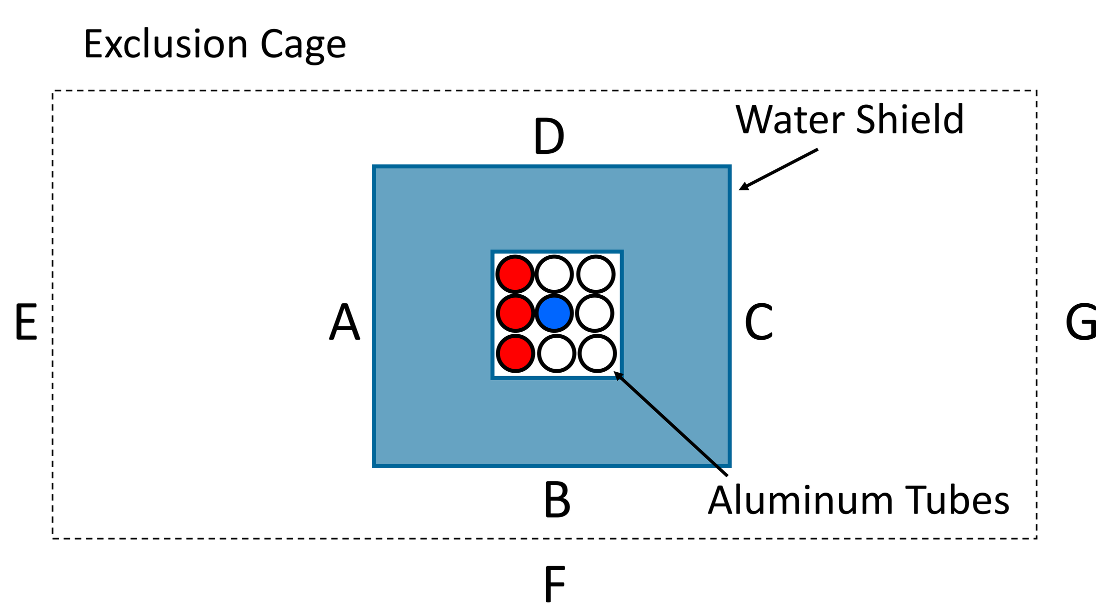

Figure 3. Top view of source facility with detector locations marked, Am-Be source locations marked with red and proposed source location marked with blue

- The neutron source is a homogeneous compressed mixture of ^{241}Am and ^{9}Be with yield of 2 to 2.46E6 n/s per Ci, equation (1) shows the (α,n) reaction

$$^{9}\text{Be} + \alpha \rightarrow {}^{12}\text{C} + \text{n} + 4.44\text{ MeV } \gamma \qquad (1)$$

- Figure 4 shows the energy spectrum of the neutrons generated by the (α,n) reaction

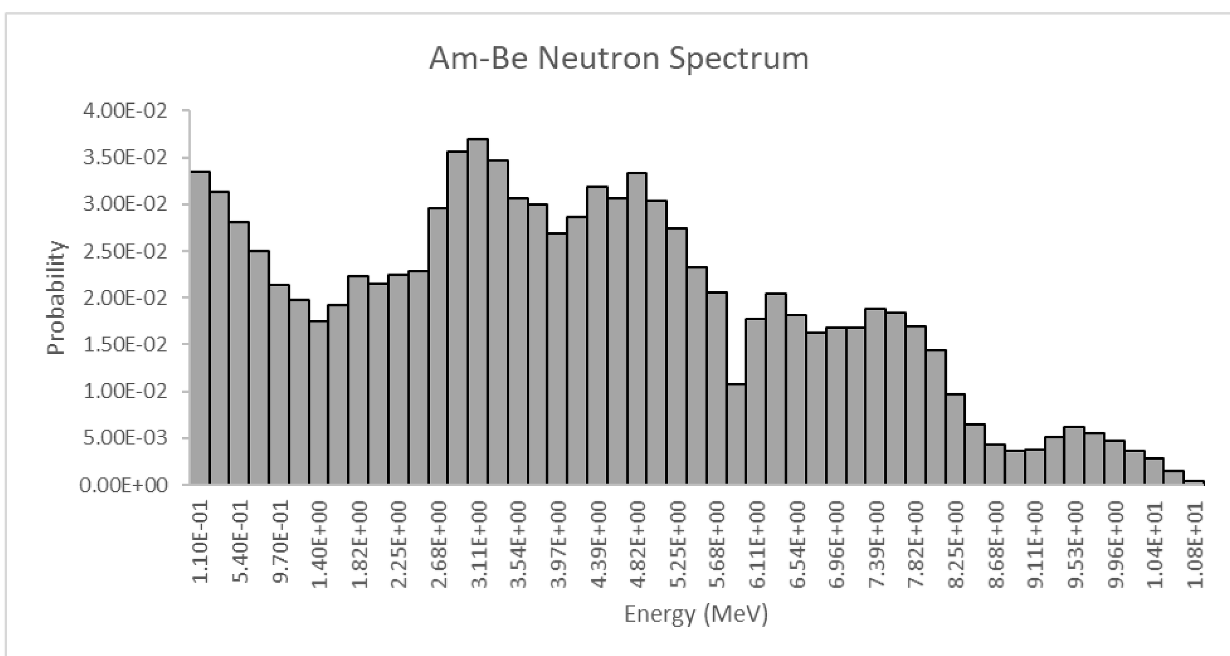

Figure 4. Americium-Beryllium neutron spectrum used in MCNP model [2]

- To verify the code, dose rates were tallied in locations with respective calculated values
- With a verified model, the addition of the fourth source was simulated and dose rates were tallied at exact locations of physical detectors

RESULTS

Table 1 shows the comparison of experimental results against MCNP results at respective detector locations.

Table 1. Am-Be source (3) configuration

Detector Location	Sources Raised (Irradiation)			Sources Lowered (Storage)		
	Physically Measured Dose Rate (µSv/h)	MCNP Dose Rate (µSv/h)	% Error	Physically Measured Dose Rate (µSv/h)	MCNP Dose Rate (µSv/h)	% Error
A	20.0±4.0	24.29	17.66	5.0±1.0	5.21	4.03
B	20.0±4.0	24.14	17.15	3.0±0.6	4.89	38.65
C	20.0±4.0	24.40	18.03	5.0±1.0	5.12	2.34
D	20.0±4.0	25.39	21.23	5.0±1.0	5.15	2.91
E	**1.0±0.2**	1.10	9.09	Undetectable	0.09	-
F	**1.0±0.2**	1.36	26.47	Undetectable	0.12	-
G	**1.0±0.2**	1.11	9.91	Undetectable	0.10	-

Similar results were achieved using MCNP as those measured using detectors, effectively verifying the model for further use. Using the verified model, the addition of the 40 mCi Am-Be source was simulated. The results are depicted in Table 2.

Table 2. Calculated dose rates at detector locations following addition of fourth Am-Be source

Detector Location	Sources Raised (Irradiation)		Sources Lowered (Storage)	
	MCNP Dose Rate (µSv/h)	MCNP Associated Error	MCNP Dose Rate (µSv/h)	MCNP Associated Error
A	32.381	±0.003	6.941	±0.007
B	32.188	±0.003	6.520	±0.007
C	32.536	±0.003	6.832	±0.007
D	33.856	±0.003	6.862	±0.007
E	**1.469**	±0.016	0.118	±0.049
F	**1.814**	±0.016	0.169	±0.062
G	**1.481**	±0.015	0.129	±0.049

The dose rates outside of the exclusion cage (locations E, F, and G) do not exceed 2.5 µSv/hr with the addition of the fourth source, even with all four sources in the irradiation position.

CONCLUSION

An MCNP simulation of a fourth 40 mCi source into the neutron source facility at UOIT has shown that the dose rate outside of the cage is still below 2.5 µSv/h. The model will be of great use to faculty research and future work will involve transferring the fourth source into the facility.

REFERENCES

[1]R. Zavatti, T. J. Price, S. Perera, "The development of a Monte Carlo Model of an Americium- Beryllium Neutron Source Facility", Proceedings of the 37th Annual CNS/CAN Student Conference, Toronto, Ontario, Canada, 2013 June 9-12.

[2] "Compendium of Neutron Spectra and Detector Responses for Radiation Protection Purposes", *International Atomic Energy Agency,* Vienna, Austria, 2001.