The Development of a Monte Carlo Model of an Americium-Beryllium Neutron Source Facility

Ricardo Zavatti[1], Terry J. Price[1], Sharman Perera[1]
University of Ontario Institute of Technology[1]
riccardozavatti@hotmail.com

Summary

A computational model of the Americium-Beryllium neutron source facility at the University of Ontario Institute of Technology was developed using the neutron transport code Monte Carlo Neutron Particle from Los Alamos National Labs. This model was built using publically available reference data, and measurements of the facility. The results from this model were validated against Nested Neutron Spectrometer readings.

1. Introduction

A common radioisotope neutron generator is the Americium-Beryllium (AmBe) neutron source which uses the (α,n) reaction to generate neutrons. An AmBe neutron source was built at the University of Ontario Institute of Technology (UOIT) to facilitate experiments with low flux neutron fields.

In order to expedite experimental processes which use the AmBe neutron source, it is often desirable to have some sort of computational model of the neutron source. With a computational model, experiments can be simulated before they are actually run. In this way, an approximation of results can be obtained without any need to enter into the facility itself. Furthermore, this also improved facility security by preventing superfluous access to the laboratory.

The AmBe neutron source facility is built inside a concrete room inside of the engineering building. (see figure 1)

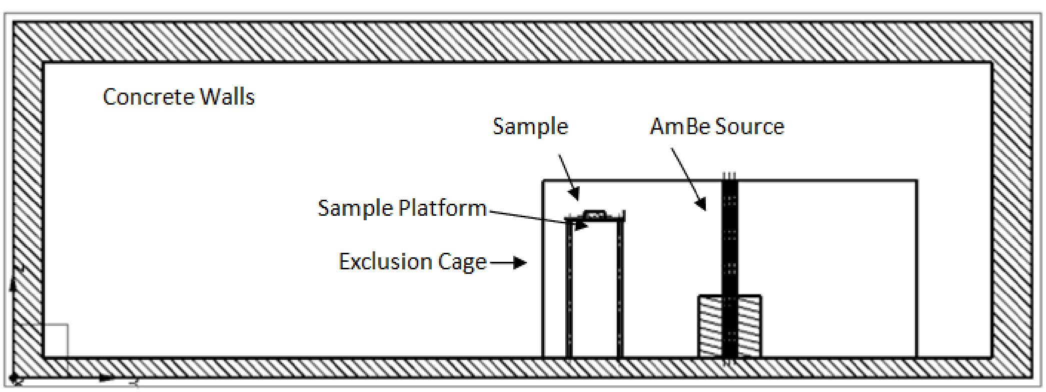

Figure 1: Side View of the UOIT Neutron Source Facility

The neutron source itself is encaged within a safety apparatus which allows it to be either raised or lowered from a water shield, and a sample to be moved a distance towards or away from the neutron source. (see figure 2)

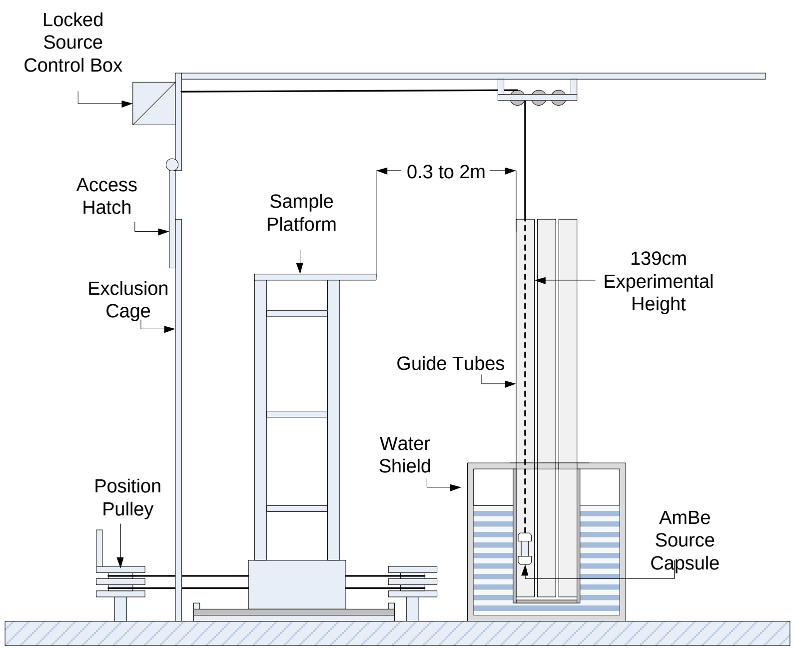

Figure 2: Neutron Source Safety Apparatus

A model of the AmBe neutron source, room, and safety apparatus was developed using the neutron transport code Monte Carlo Neutral Particle (MCNP) from Los Alamos National Labs. Reference data from various sources was used to generate the model and the model was validated against spectra measurements taken by a Nested Neutron Spectrometer (NNS) [1].

2. Materials and Methods

Geometry for the model was taken from manual measurements taken of the facility as well as drawings of the room as well as equipment. Measurements taken from drawings were verified with manual measurements.

Several geometric simplifications were made of the facility: these included removing dry-wall from the wallsof the facility, removing the security cage (which is by in large empty space), removing the source positioning apparatus, and simplifying the sample platform apparatus to a single aluminum sheet.

Material properties were obtained from the *Compendium of Material Composition Data for Radiation Transport* [2]. The spectrum for the AmBe neutron source itself was generated from the IAEA's *Compendium of Neutron Spectra and Detector Responses for Radiation*

Protection[3]. Conversion factors between source activity and neutron production were found in Shlein's *Handbook of Health Physics and Radiological Health* [4].

After the model was generated, a detector in the model was placed above the sample platform 0.3m away from the neutron source such that it recreated a previously run experiment in which the spectrum was reconstructed from measurements from a Nested Neutron Spectrometer. A run was performed and a neutron spectrum was generated. This computationally produced spectrum was normalized and compared to the experimentally obtained spectrum, and in this way the model was validated.

3. Results and Interpretation

When the computationally generated neutron spectrum is compared to the experimental spectrum (see figure 3), it is found that they match well with a correlation coefficient of 0.85.

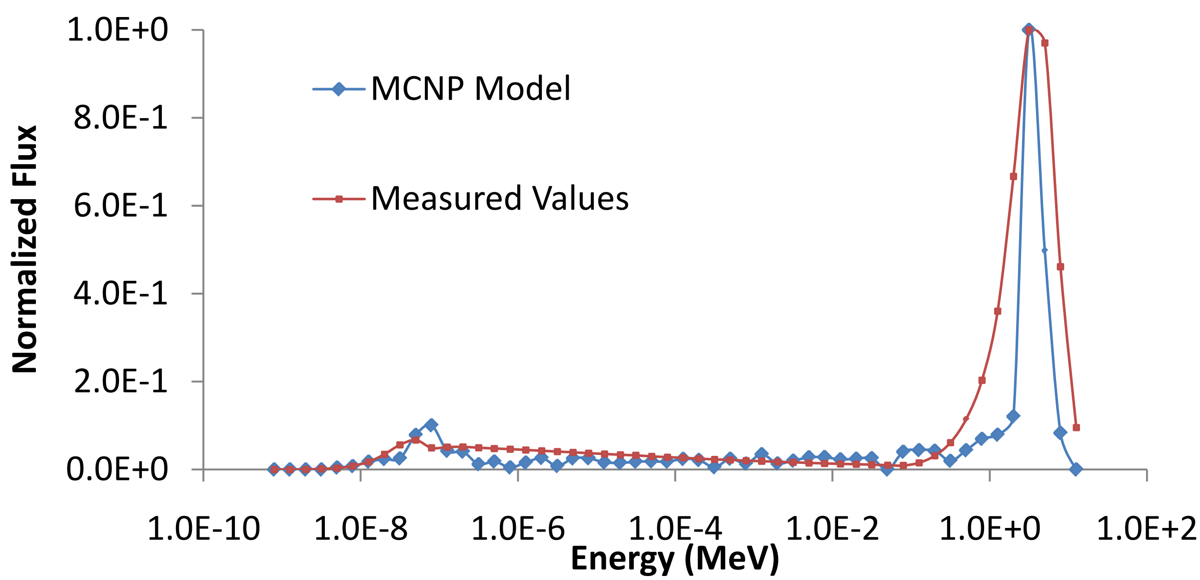

Figure 3: Experimental vs. Computational Neutron Spectra

In these results, it is clear that both the fast and thermal neutron peaks from the AmBe source visible. The fast peak in the measured values appears to be much broader than the modeled fast peak, and the thermal peak appears to have a lower relative magnitude in the measured values than the modeled valuesIt ought to be noted that the experimental data was sparser than the MCNP data and this results in some poor comparison between data sets.

4. Conclusion

In conclusion, a MCNP model of the UOIT AmBe neutron source facility was developed. This model can be used to computationally test many experiments and thereby minimize laboratory access and thus increase laboratory security. Comparison between generated neutron spectra and experimentally obtained neutron spectra gives good evidence to believe that this model is a good approximation of the actual physical phenomenon that are present in the neutron source facility.

5. Future Work

Future work on the model can be done in two categories: Improvement of model accuracy and improvement of validation.

To improve model accuracy, the simplifications to the model made during the modeling process could be taken out – IE adding in drywall, adding in the security cage, and completing the sample platform apparatus. Furthermore, a simplified model of adjacent rooms and hallways could be added to improve backscatter accuracy.

To improve validation, the actual Nested Neutron Spectrometer could be modeled in MCNP, and the detector response modeled. This would enable a direct comparison of detector responses.

6. Acknowledgments

We would like to acknowledge Mr. Dave Goreman for his work certifying the neutron source with the regulator, Mr. Jaque Dubeau for his measurements of the neutron spectrum with his Nested Neutron Spectrometer, and Dr. Rachid Machrafi for his work building the AmBe neutron source.

References

[1] R.G. Williams III, C. G. (2006). *Compendium of Material Composition Data for Radiation Transport Modeling.* Richland: Pacific Northwest National Laboratory.

[2] J. Dubeau Et. Al (2010) *A New Type of Neutron Spectrometer Using Nester Moderator*. IEEE NPSS: International Workshop on Real Time Measurement, Instrumentation & Control

[3] International Atomic Energy Agency (2001) *Technical Report Series No. 403: Compendium of Neutron Spectra and Detector Responses for Radiation Protection Purposes Supplement to Technical Report Series No. 318*

[4] Bernard Shlein, L. A. (1998). *Handbook of Health Physics and Radiological Health Third Edition.* Baltimore: Lippincott Williams and Wilkins.