Neutron Flux and Dose rate mapping around the experimental 16Ci AmBe source facility at Manipal University

Subbaiah K. V.*, Priyada P., P. K. Sarkar and M. Gupta,
Manipal Centre for Natural Sciences, Manipal University, Manipal 576104, INDIA
*email: kv.subbaiah@manipal.edu

Introduction

Portable neutron sources are widely employed in many areas of practical applications and in research. For instance, Americium-Beryllium (Am-Be) sources are extensively used for oil well logging, neutron radiography, cancer treatment, densitometry, trace element analysis, neutron dosimetry and a host of other areas of research. The 16Ci Am-Be (yield 4.0e+07 neutrons/sec) source facility developed at the Manipal Centre for Natural Sciences, Manipal University and is being operationalized.

A thorough study on neutron beam characterization is underway to determine prevailing dose rates for both gamma radiation and the neutron spectrum for the experimental volume of 40x70x40 cm currently available. SS-304 material of 2 mm thick is used as a lining material. Fig.1 shows the photograph of neutron dose rate measuring apparatus at the exit of collimated beam hole (Borated HDPE block with central hole). In this paper we explain the computational models assumed and present an inter-comparison of results on neutron fluxes and dose rates. Results are preliminary and the characterization of the source is a continuous process.

Materials and Methods

For carrying out computations, a Monte Carlo code MCNP [1] is used. This is a general purpose code for simulation of transport of coupled neutral and charged particles in bulk media. It employs by option group wise or point cross sections, which include major physical processes of interaction between radiation and matter, for simulating the transport of radiation. It treats an arbitrary three-dimensional configuration of materials in geometric cells bounded by first- and second-degree surfaces and fourth-degree elliptical tori. Important standard features that make MCNP very versatile and easy to use include a powerful general source, criticality source, and surface source; both geometry and output tally plotters; a rich collection of variance reduction techniques; a flexible tally structure; and an extensive collection of cross-section data. Energy ranges are from 10-11 to 20 MeV for neutrons with data up to 150 MeV for some nuclides, 1 keV to 1 GeV for electrons, and 1 keV to 100 GeV for photons. For simulation of results, the details of AmBe source details and source housing and embedded structures are modeled as built. Various tallies compatible with experimental results such as fluxes, dose rates and reactions in various foils at different locations in the experimental area are simulated and are presented under results and discussion section.

Fig.1: Neutron dose rate measuring apparatus

On the other hand, neutron area monitor, survey meter and some activation foils are used to characterize the neutron beam. Geiger-

Müller counter survey meter employed for measuring gamma ray dose rates at different locations. These preliminary results are also presented in sequel.

Results and Discussions

Table.1 Comparison of neutron flux for AmBe source

Activation foil			
^{198}Au		^{116m}In	
Cal. (Bq)	Expt. (Bq)	Cal. (Bq)	Expt. (Bq)
297	237.0	437.5	417.9
*Neutron Flux(n-cm-^{2}sec-^{1})			
4.6e+4	4.7e+3	4.6e+4	4.3e+3

*Neutron flux arrived at by assuming neutron activation cross section 100 barn and 154 barn for ^{198}Au and ^{116}In^{m} respectively.

Dist. *(cm)	Cal. Dose rate (R/h)	Expt. Dose rate(R/h)
10	5.281	6.337
25	1.567	1.727
50	0.613	0.567
70	0.343	0.291

*measured from centre of the source perpendicular to its axis

Monte Carlo simulations have been carried out by accounting in details of Am-Be source geometry, source housing structures, stainless steel linings and embedded structures as built. The output results required are neutron fluxes, dose rates and (n,γ) reactions in gold, indium and magnesium for which preliminary evaluations are done. Measurements are made at corresponding points. Table-1 shows the results. It can be noticed that the differences of about 50% exist between theory and simulations. These are caused on the one hand due to the statistics of counting, the estimation of the detection efficiency and errors that might have crept into the simulations due to large resonances in the radiative capture cross sections present in the selected foils.

Further studies are underway.

References

[1] Briesmeister, J. F,(Ed), MCNP, LA-13709- M Manual, 2000