Comparison of measured and calculated dose rates of Am-Be source with Monte Carlo simulation.

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Abstract: *Monte Carlo simulations (MCS) results for dose rates at an experimental location are compared with measured values of Am-Be source housed in a concrete bunker. The dose rates comprises of both neutron and gamma radiations emitted from the source. The gamma dose rates for 4.44 MeV (emitted from the source) and 2.2 MeV (capture gamma rays from the concrete) are deduced from the count spectrum obtained with 2"×2" NaI(Tl) crystal (available in the literature[1]). The neutron and total gamma dose rates calculated using MCS and compared with the measured neutron and total gamma dose rates are in mostly good agreement.*

Introduction:

Am-Be sources are widely employed to carry out both neutron and gamma radiation experiments such as activation foils etc. To carry out the experiments safely, the source has to be housed in a suitable container. The radiation fields around the source are required to carry out experiments. In the present work, MCS have been carried out for dose rates due to neutron and gamma rays for a particular location, where experimental results are available enabling comparison between them.

Material & Methods:

The present experimental facility has a 16 Ci Am-Be source housed inside a concrete bunker, which emits 4×10^7 neutrons/s[1] and 3×10^7 photons/s[2]. The gamma dose rates due to 4.4 MeV and 2.2 MeV are deduced from the count spectrum obtained with 2"×2" NaI(Tl) crystal[1]. The neutron and gamma dose rates calculated using MCS are compared with the measured dose rates.

Results & Discussion:

MCS results compared with measured dose rates for Am-Be source of strength 16 Ci housed in a concrete bunker which emits 4×10^7 neutrons/s[1]. Am-Be source emits neutrons besides it emits 4.44 MeV gamma ray with sufficient intensity produced from the ^{13}C excited state, whose strength is 3×10^7 photons/s (0.75 photons per neutron[2]). The gamma ray of 59.5 keV emitted by Am source does not contribute to the dose rate at experimental location since it gets absorbed by the SS structure present around the source. MCS have been carried out accounting the bunker structure in detail. The computations include the dose rates due to both neutron and gamma (source and capture gammas) and are presented below.

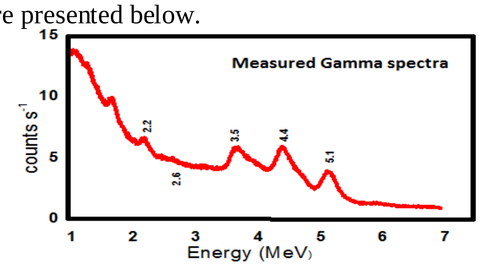

Figure 1 - Measured gamma spectra (reproduced from reference 1)

A. Comparison of Neutron dose rate: The neutron dose rate measured at 85 cm away from the source mid plane with Gamma neutron survey meter is compared with the calculated dose rate and are in excellent agreement with each other (shown below).

MCS dose rate: 2036.8 µSv/hr
Measured dose rate: 1985.0 µSv/hr

B. Deduction of dose rates for 4.44 MeV & 2.2 MeV gamma from NaI (Tl) count spectrum: Gamma dose rate mainly comprises of 2 components viz. 4.44 MeV source gamma (emitted by the source) and 2.2 MeV capture gamma. The flux at these values are deduced from the count spectrum(Fig.1) measured at 85 cm from the source. The resulting dose rate are compared in table 1 and are in good agreement.

Table 1– Comparison of dose rates

Parameters		4.44 MeV	2.2 MeV*
FWHM(KeV)		223	128
channels		52	67
Counts(s^{-1})	4.44 MeV	215.45	70.47
	3.42MeV†	34.7	
Efficiency of detector		3.4 %	6.0 %
Photons (p/cm².s)		293.58	46.6
Dose rate (µSv/hr)		**15.85±0.8**	**1.99±0.03**
MCS dose rate (µSv/hr)		**16.11±0.1**	**1.59±0.01**

*Capture gamma by $^1H(n,\gamma)^2H$ interaction.
† Double escape peak of 4.44 MeV.

C. Comparison of total dose rate by gammas: The total gamma dose rate measured with GM survey meter compared with MCS result.

Measured total dose rate: 9.0 µSv/hr
Simulated total dose rate: 17.84 µSv/hr

Conclusion:

The neutron dose rate calculated is in good agreement with the measured dose rate. However, the under estimate of measured total gamma dose rate might have resulted due to less sensitivity of GM counter for 4.44MeV gammas.

References:

1. P. Priyada & P.K. Sarkar, "*Use of prompt gamma emissions from polyethylene to estimate neutron ambient dose equivalent*", Nuclear Instruments and Methods in Physics Research A 785 (2015) page 135-142.
2. Isao Murataa et al, "*Neutron and gamma-ray source-term characterization of AmBe sources in Osaka University*", Progress in Nuclear Science and Technology Volume 4 (2014) page 345-348.