Monte Carlo Simulation of Pu-Be, Am-Be and Cf-252 neutrons Backscattering from buried explosives in dry soil

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Abstract— **Two different geometrical arrangements of neutron source buried landmine and detector with and without carbon reflector were modeled. Monte Carlo calculation of elastically Backscattered (EBS) neutrons from hidden land-mines were conducted. The results obtained show that the sensitivity of elastically backscattered neutrons (EBS) for landmines detection strongly depends on the type of the source used and the presence or absence of a carbon reflector.**

Keywords- MCNP, neutron backscattering, land mine detection.

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I. INTRODUCTION

This Neglected landmines from past and present armed conflicts continue to pose a risk to populations in more than 60 countries in the developing world. A typical anti-personnel or anti-tank landmine contains very little metal and is therefore difficult to detect by means of traditional normal metal detection techniques. Very sensitive metal detectors can detect low-metal content landmines, but they are insensitive in distinguishing between mines [1]. The mined areas are, indeed, close to the battlefields, being consequently heavily polluted by metal pieces from the explosions of different ordnances. Consequently, there is a strong need for a technological breakthrough in this field to definitively solve the land-mine problem without delay. National, international, non-governmental organizations and institutions acknowledged the need to improve a method for non-destructive characterization and detection of land-mines buried in soil. Accordingly, growing interest in methods that potentially could detect the chemical signature coming from the mine casing or the explosive material contained in the mine has been reported with several suggested methods of land mine detection based on different nuclear interaction [2 - 7].

A previous work in our group [1] showed results the neutron backscattering method is sensitive to shield configuration, soil type, source type and source height. The best results were observed with 252Cf source at 3.0cm above the soil when the landmine is buried in dry porous soils. The study confirmed the superiority of 252Cf as compared to Pu-Be source when utilized for landmine detection. The main objective of this paper is to optimize geometrical arrangement for elastically backscattered neutron method of detection of anti-tank landmine using three different isotopic neutron sources via Monte Carlo simulations.

II. METHOD

MCNP is a three-dimensional, point wise, continuous energy cross section Monte Carlo Code, which is capable of performing neutron, photon, or coupled neutron/photon transport calculations [8]. The code uses continuous-energy, nuclear and atomic data libraries, the primary sources of which are obtained from the Evaluated Nuclear Data File (ENDF) system [9]. The evaluated data are processed into a format appropriate for MCNP with the help of NJOY code [10]. Nuclear data tables exist for different types of neutron interactions from which appropriate ones may be selected through unique identifiers for each table, called ZAIDs. Continuous nuclear cross section data based on the ENDF/BVI were used in the present computations.

Fig (1) shows the geometrical arrangements used in these present calculation as modeled by MCNP. It consists of dry soil of dimensions100cm×40cm×40cm and carbon reflector of dimension 100cm×40cm×5cm, located 20cm above the surface soil. A cylindrical land-mine model is used to represent the Anti tank- M15 of dimensions 14.85cm×12.5cm coated by steel of thickness 2cm. The mine was assumed to be buried 5cm deep in the soil. Three different isotropic neutrons sources Pu-Be, Am-Be and Cf-252 were assumed alternatively located above the soil at y=11cm. Measured and normalized energies neutrons spectra of the sources used in these calculation were taken from [11]. A ring detector of radii 5, 15, 20, 25 and 35cm was assumed located at the same level of the source. The type of anti tank used in these calculations is the one of the landmines planted in Sudan. Calculations were performed using a fixed point source with enough history to have the statistical error less than 0.01% in all energy bins. The composition of soil, TNT, RDX, Steel, and carbon as modeled in this present MCNP simulations are shown in Table 1, with the data taken from Refs. [12 - 14].

Table 1: Composition of materials for the landmine model

Material	Density	Elemental mass fraction/mass density (g/cm^{-3})						
	Density g/cm^3	H	C	N	O	Si	Al	Fe
Soil	1.12	0.0145	-	-	0.55	0.36	0.08	-
Carbon	1.27	-	1	-	-	-	-	-
Steel	7.82	-	0.005	-	-	-	-	0.995
Explosive	1.65	0.0262	0.251	0.298	0.4244	-	-	-

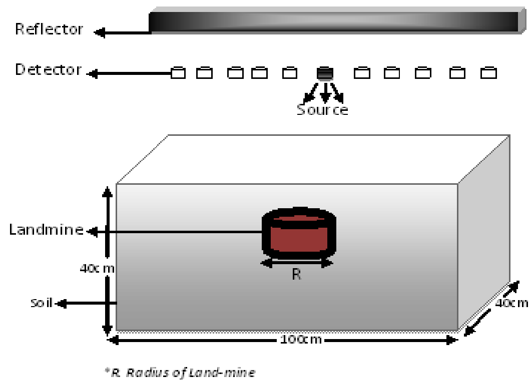

Fig. 1: Simulated landmine detector model

III. RESULTS AND DISCUSSION

As shown in Fig .2, higher net EBS relative yield of Cf-252 neutrons from antitank-M15 with carbon reflector is observed within energy range from 0.005 to less than 0.4 MeV, compared with results obtained for Cf-252 without carbon reflector and Pu-Be and Am-Be with and without carbon reflector. A higher net backscattered relative neutron yield is observed within energies range greater than 0.4 MeV and less than 1MeV for Cf-252 without reflector as compared with results obtained with Cf-252 with reflector and Pu-Be and Am-Be with and without carbon reflector. This may be attributed to the fact that the average energy of Cf-252 sources is about 2.35 MeV.

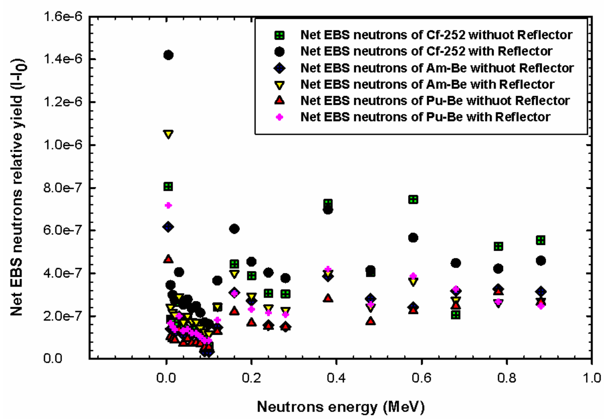

Fig. 2: EBS neutrons energy spectra from hidden Anti Tank land-mines M15 with and without carbon reflector within energy range 0.005 and less than 1.0 MeV for Cf-252, Pu-Be and Am-Be neutrons sources.

Fig. 3 shows higher net relative backscattered Pu-Be neutrons detected from antitank-M15 without reflector over all energy ranges (from 1.4 MeV and less than 7.0 MeV) when compared with Pu-Be with carbon reflector and Cf-252 and Am-Be with and without carbon reflectors. This may be attributed to the fact that the average energy of Pu-Be is about 5.0 MeV. Lower net EBS relative yield is scored for the three neutron sources with and without carbon reflector in energy rage 3.6-7.0 MeV.

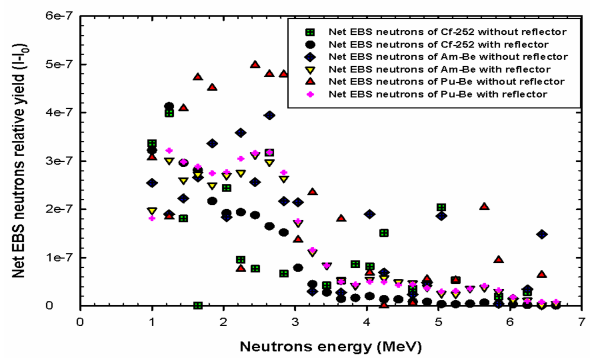

Fig. 3: EBS neutrons energy spectra from hidden Anti-Tank land-mines M15 with and without carbon reflector within energy range 1.0 and less than 7.0 MeV for Cf-252, Pu-Be and Am-Be neutrons sources.

The variations of net spectral EBS neutrons of Cf-252, Pu-Be and Am-Be from anti tank M15 with detector radii within neutrons energy range 0.005 and less than 1.0 MeV is shown in Fig.(4). High net relative spectral yield neutrons is observed for Cf-252 neutron source as compared with Pu-Be neutrons source, while higher net EBS neutrons within neutrons energy range 1.0 and 7.0 MeV is observed for the Am-Be when compared with Pu-Be neutron source (data not shown). The variation of signal to background ratios with detector radii within energy range from 0.005 and less than 1.0 MeV for the three sources. Lower signal to background ratio was noticed for Cf-252 but higher single to background ratio is observed for Pu-Be. This can be attributed to the lower background of Pu-Be EBS neutrons and higher background of Cf-252 within this energy range.

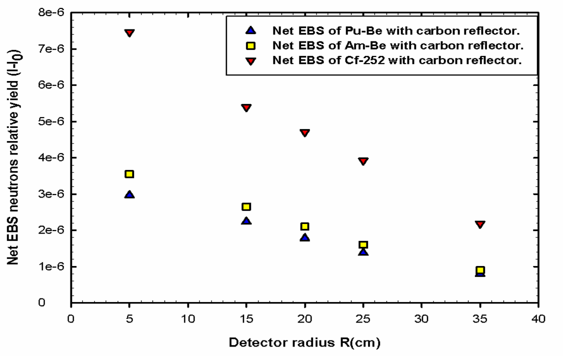

Fig.4: **Variation of net EBS neutrons relative yield from hidden Anti tank-MI 5 within energy range from 0.005 and less than 1.0 MeV with detector radius for different neutrons sources Pu-Be, Am-Be and Cf-252 with carbon reflector.**

IV. CONCLUSION AND FUTURE WORK

Monte Carlo simulations of EBS neutron energy spectra from Anti tank for Pu-Be, Am-Be and Cf-252 neutron sources with and without carbon reflectors were performed. The effects of carbon reflector on the net EBS neutron and signal background ratio with detector radii were studied. The presences of carbon reflector and type of sources have strongly effects of sensitivity of the (EBS) method as well. Future work plans involve the influence of humidity on the device sensitivity.

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