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Monte Carlo assessment of soil moisture effect on high-energy thermal neutron capture gamma-ray by ^{14}N

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Abstract

Among many conventional techniques, nuclear techniques have shown to be faster, more reliable, and more effective in detecting explosives. In the present work, neutrons from a 5 Ci Am–Be neutron source being in water tank are captured by elements of soil and landmine (TNT), namely ^{14}N, H, C, and O. The prompt capture gamma-ray spectrum taken by a NaI (Tl) scintillation detector indicates the characteristic photo peaks of the elements in soil and landmine. In the high-energy region of the gamma-ray spectrum, besides 10.829 MeV of ^{15}N, single escape (SE) and double escape (DE) peaks are unmistakable photo peaks, which make the detection of concealed explosive possible. The soil has the property of moderating neutrons as well as diffusing the thermal neutron flux. Among many elements in soil, silicon is more abundant and ^{29}Si emits 10.607 MeV prompt capture gamma-ray, which makes 10.829 MeV detection difficult. The Monte Carlo simulation was used to adjust source–target–detector distances and soil moisture content to yield the best result. Therefore, we applied MCNP4C for configuration very close to reality of a hidden landmine in soil.

Keywords: Monte Carlo simulation; Landmine detection; ^{14}N prompt capture gamma

1. Introduction

In the last decade, significant efforts have been carried out by several research institutions and industrial companies in the field of explosive detection and demining using nuclear techniques (Pesente et al., 2001). The present status of such investigations carried out under the IAEA CRP has been summarized in a special issue of Applied Radiation and Isotopes (Csikai et al., 2004). In view of the many hundred thousands of landmines left buried in the western part of Iran after cessation of the eight-year war (1980–1988) between Iraq and Iran, many people in particular, children have lost their lives or become disabled. As a humanitarian effort, we are trying to exploit the neutron capture technique by the detection of high-energy capture gamma-ray, 10.829 MeV (Tuli, 1999), emitted in the de-excitation of ^{15}N in landmines and consequently leading to detecting the AP landmine (Hsiao-Hua and Kearfott, 1999; Pesente et al., 2001; Maucec and Rigollet, 2004). The technique is related to the detection of hidden explosives using thermal neutron-induced reactions in ^{14}N, which is abundant in most explosives. The advantage of this technique lies in the fact that no other radioisotope emits such a high energy with high probability. The only exception is ^{29}Si which emits a high-energy gamma-ray of 10.607 MeV but with low

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