Characterization of strong ^{241}Am sources

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Introduction

^{241}Am is a radionuclide that can be used in contexts such as ionization smoke detectors where ^{241}Am is used in small amounts. Stronger ^{241}Am sources are used in industrial gauging applications and in combination with low Z isotopes such as beryllium or lithium, as a neutron source. However, the useful applications of strong ^{241}Am sources in society also entails that the sources may be susceptible to theft or other illegal activities. By building national nuclear forensics libraries (NNFL), information about radioactive sources and nuclear material in a State can be kept in order to track the origin of a source when necessary. This information may, besides visual information and serial numbers, be information inherent in the source.

The aim of this work was to investigate the possibility of using gamma spectrometry to find inherent signatures in order to discriminate between different ^{241}Am sources in cases when visual signatures may not be accessible. The investigated signatures are age and impurities. Furthermore, Monte Carlo simulations have been used to clarify and explain the origin of the impurities seen in the gamma spectra.

Method

Measured sources:

- Source 1: Sealed 185 GBq ^{241}Am source
- Source 2: Sealed 185 GBq ^{241}Am source
- Source 3: Sealed 3.7 GBq ^{241}Am source
- Source 4: Electroplated ^{241}Am source
- Source 5: Smoke detector

Sources 1-4 were measured at a distance of about 30 cm using a portable p-type coaxial high purity germanium detector (Detective-EX, EG&G Ortec, Oak Ridge, TN, USA). Source 5, the smoke detector, was measured for comparison. This spectrum was acquired with a p-type coaxial HPGe detector (EG&G Ortec, Oak Ridge, TN, USA).

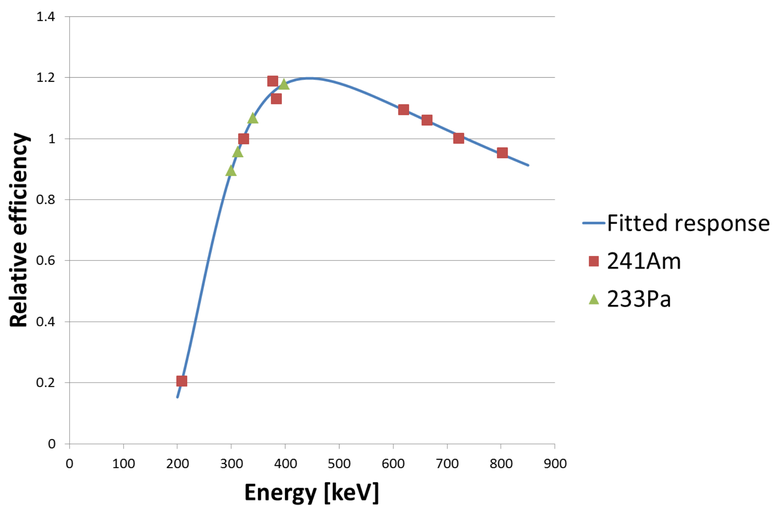

Figure 1. *Fitted response; the line corresponds to the parameterization of the response curves*

In order to characterize the response of these particular measurement setups, intrinsic response functions were established using a number of ^{241}Am gamma lines covering energies from 59.5 to 801.9 keV and the response, *i.e.* the relative efficiency, curves were fitted to an empirical polynomial, see Fig.1.

Table 1. *Some of the identified gamma lines from nuclides other than ^{241}Am and suggested reactions on impurities. The nuclides with an asterisk are emitting gamma rays due to de-excitation.*

Energy [keV]	Reaction	$t_{½}$
440	^{23}Na (α, α′) ^{23}Na*	1110 fs
1129	^{23}Na (α, pγ) ^{26}Mg*	141 fs
	^{23}Na (α, nγ) ^{26}Al	417 ky
1779	^{23}Na (α, pγ) ^{26}Mg*	6440 fs
1808	^{23}Na (α, pγ) ^{26}Mg*	476 fs
	^{23}Na (α, nγ) ^{26}Al	417 ky

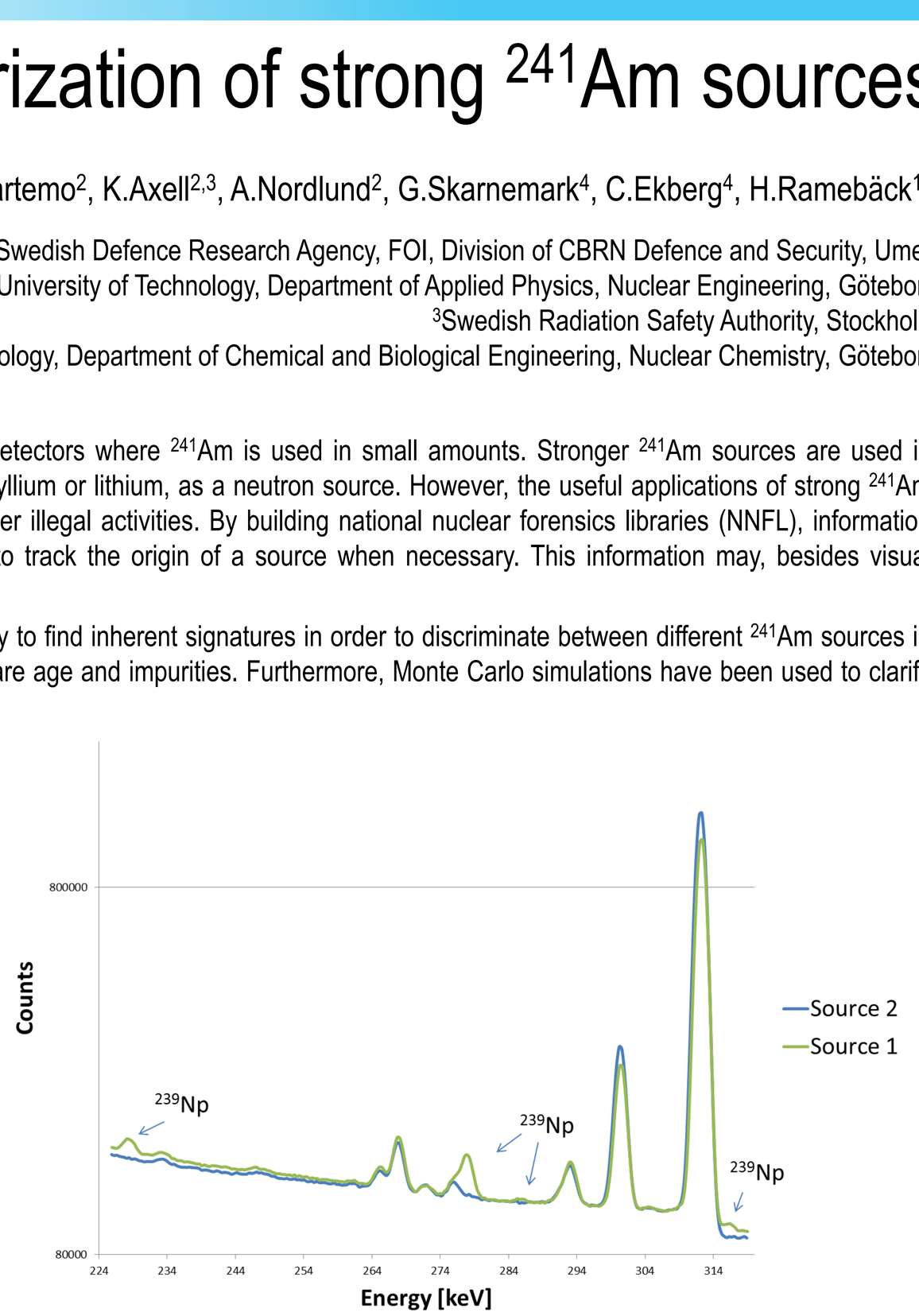

Figure 2. *Excerpt of spectra of source 1 and 2*

Results

The gamma spectra of Sources 1-3 have a number of peaks that cannot be derived from ^{241}Am. Some of these energies together with suggested reactions are presented in Tab. 1. Many of these peaks do not have a Gaussian shape but are doppler broadened. This is in itself an indication that there are other, light, elements present and that there are nuclear reactions taking place within the source.

The calculated ages of the sources are presented in Tab. 2. The 322.6 keV ^{241}Am line and the 311.9 keV gamma line of ^{233}Pa were used for the age determination. The combined uncertainty includes uncertainties in decay constants, photon yield, counting statistics and the fitted response. The age of Source 4 was known; the separation and the subsequent electroplating was performed in 2001, which is in good agreement with the measured age.

Two of the spectra (from Source 1 and Source 3) showed peaks that can be identified as ^{239}Np. This could imply that these sources contain some ^{243}Am as an impurity, since ^{239}Np is the daughter of ^{243}Am. The gamma lines of ^{243}Am are too weak to be measured directly in these sources with gamma spectrometry. The Source 2 spectrum did not show these peaks, see Fig. 2.

Table 2. *Results from the age determination of the different sources*

Source	Age [y]	Uc [y] *k*=2	Separation date
Source 1	31.4	2.0	1982-01-06
Source 2	40.8	2.6	1972-07-18
Source 3	43.9	3.6	1969-07-06
Source 4	12.2	2.3	2001-06-25
Source 5	21.5	6.9	1985-07-09

Conclusions

In this paper we have shown that it is possible to distinguish between five ^{241}Am sources that have been investigated using gamma spectrometry. This information may be useful when visual information of the sources is not available, for example in an investigation of attribution of an orphan source, or in a nuclear forensic investigation.