# Soil Isotopic abundances reconstructed by using simulated spectra

G.P. Bezzon[1], G.P. Buso[1], C. Broggini[2], A. Caciolli[2,3], I. Callegari[3], T. Colonna[3], G. Fiorentini[1,4,5], E. Guastaldi[3], F. Mantovani[4,5], G. Massa[3], R. Menegazzo[2], L. Mou[1], C. Rossi Alvarez[1], M. Shyti[4,5], M. Kaçeli Xhixha[7], G. Xhixha[4,5,6], A. Zanon[1]

[1] *INFN, Legnaro National Laboratory, Legnaro (Padova), Italy.*
[2] *INFN, Padova Section, Padova, Italy.*
[3] *CGT Center for GeoTechnologies, University of Siena, San Giovanni Valdarno, Italy.*
[4] *Physics Department, University of Ferrara, Ferrara, Italy.* [5] *INFN, Ferrara Section, Ferrara, Italy.*
[6] *Faculty of Forestry Science, Agricultural University of Tirana, Tirana, Albania.*
[7] *University of Sassari, Botanical, Ecological and Geological Sciences Department, Sassari, Italy.*

## INTRODUCTION

The Rad_Monitor project's goal is to determine the concentration of radioisotopes in the Veneto territory by measuring the γ rays emitted by the ground surface. To accomplish this job, several detecting techniques have been used: rock sampling (the samples were analyzed in laboratory), in situ measurements and airborne survey. In situ and airborne detectors have to be carefully calibrated and we have developed a calibration procedure based on the reconstruction of mono-isotope spectra (hereafter called sensitive spectra) for each of the radioisotopes investigated in our analysis. The acquired in situ spectra are then fitted by using these mono-isotope spectra.

Portable detectors were calibrated in selected sites with well known concentrations of $^{40}$K, $^{238}$U, and $^{232}$Th and $^{137}$Cs. The procedure was described in detail in a previous work [1].

In this contribution, we investigate a different approach to analyze the in situ spectra and we report the preliminary achieved results .

## PROCEDURE

The method is based on simulating the sensitive spectra by using a GEANT4 code [2]. The code is described in an other contribution to this Annual Report [3].

The detector used in the measurements was a NaI(Tl) detector of 1L volume. It was piloted by a DiGiBase Ortec module which was connected to a laptop. The system was placed in a backpack. In the present code version, the detector geometry is included following the drawings from the manufacturer, but the backpack is not included in the simulation. The code simulates the γ rays, emitted from the ground and takes into account both the soil and the air absorption.

Due to this simplified description, some normalization of the simulated spectra was necessary. The normalization factor is the same for all radioisotopes and reduces the γ-ray intensity by 20%. In Figure 1 is reported the comparison between the simulated spectra (red) and the sensitive spectra determined as in [1] (black). The energy resolution of the detector is applied a posteriori by using the values provided by the experimental data.

Table 1. Radioelement concentration in the Cave Mori site obtained by the laboratory analysis (LAB) on collected samples and by fitting the in situ spectrum with the spectra obtained with the simulation (SIM).

| element | LAB | SIM |
|---|---|---|
| $^{40}$K [%] | 0.41±0.06 | 0.55±0.03 |
| $^{238}$U [ppm] | 0.85±0.21 | 0.98±0.07 |
| $^{232}$Th [ppm] | 1.70±0.42 | 1.75±0.11 |

The simulated and normalized spectra have been used to extract the elemental concentration of the rocks in Cave Mori situ. Cave Mori is in the municipal of Rovereto. This site is characterize by the presence of the a carbonate type of rock called Giallo Mori. The radioelement concentrations have also been deduced by collecting samples of its rock and by analyzing them in laboratory. The obtained values are reported in Table 1.

The acquired spectra are reported in Figure 2 with the fit obtained by using the simulated spectra. The energy range covered by the fit is from 350 to 2900 keV. The deduced concentrations are reported in Table 1. In this analysis the $^{137}$Cs spectrum was not included because its concentration was below the sensitivity of the system. The intrinsic background of the detections system, deduced during the calibration, was subtracted from the Cave Mori spectrum before the fitting procedure.

## CONCLUSION

We use the GEANT4 code developed and described in [3] to fit the spectrum acquired in the Cave Mori situ with a 1L portable NaI(Tl) detector. The simulated spectra well overlap the sensitive spectra obtained by a calibration procedure already published [1]. Up to now, the simulation do not match the sensitive spectra in absolute value and a normalization factor of 20% is needed.

The procedure has shown promising results and it could also be used in the airborne survey where the effect of spectrum deformation due to the interaction of γ rays in air,

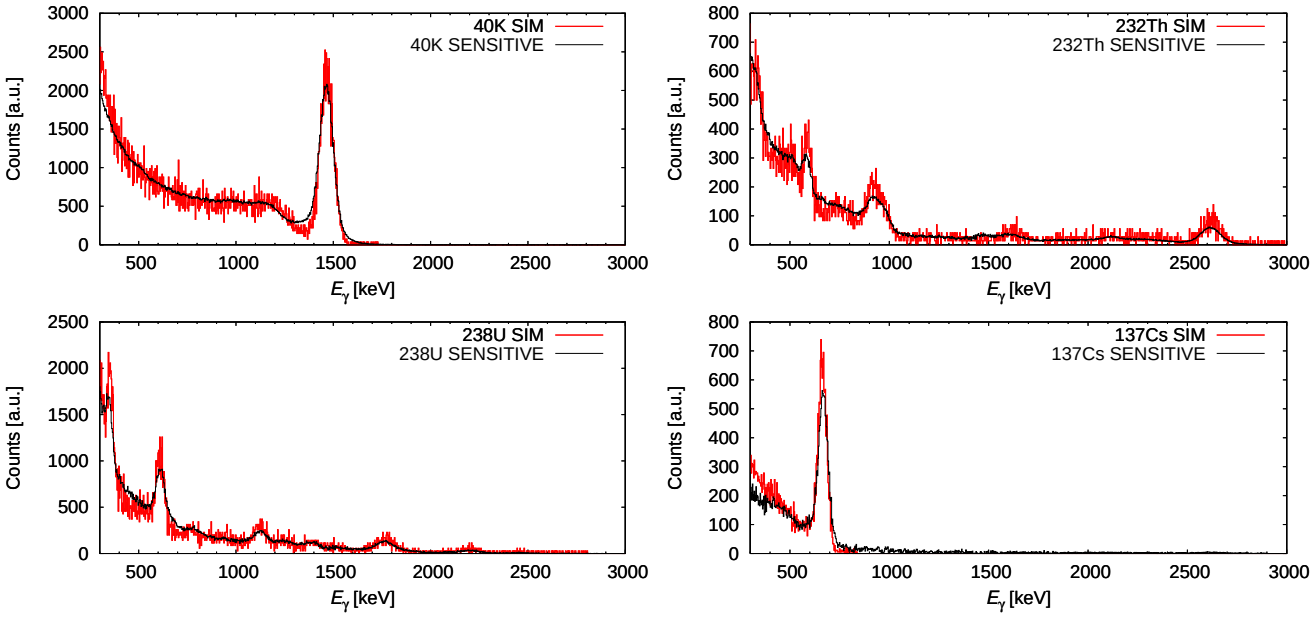


Fig. 1. The four spectra obtained with the GEANT4 code (red) for each radioisotopes and the sensitive spectra obtained with the calibration method (black).

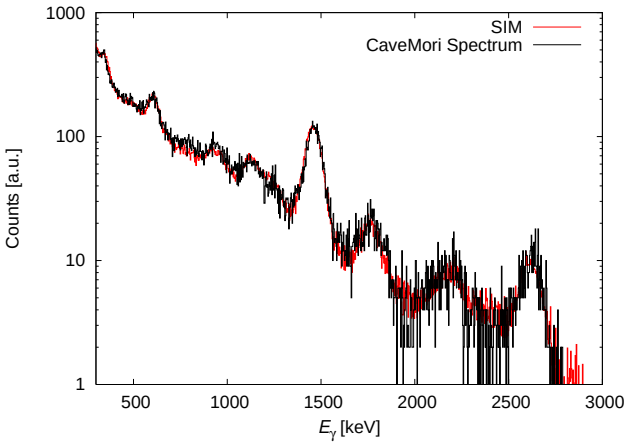


Fig. 2. The spectrum acquired in Cave Mori (black) compared with its fit by using the simulated mono-isotope spectra plus the detector intrinsic background (red).

at different altitudes, reduces the precision of the analysis if using the sensitive spectra obtained at ground level.

**Aknowledgment**

The authors would like to thank Enrico Bellotti, Di Carlo Giuseppe, Pirro Altair, Luigi Carmignani, and Riccardo Vannucci for useful suggestions and invaluable discussions. This work is supported by the Italy INFN and Fondazione Cassa Di Risparmio di Padova e Rovigo and Centro di Geotecnologie dell'Università di Siena and Tuscany region founding.

[1] A. Caciolli et al., Sc. Tot. Env. 414 (2012) 639.
[2] S. Agostinelli et al. NIMA 506 (2003) 250
[3] G. P. Bezzon et al., this LNL Annual Report
[4] Xhixha et al., LNL-Annual Report 2011, pg. 133.