First flight test on Elba Island for the Airborne γ-ray Survey System developed at LNL

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INTRODUCTION

The request of monitoring the environmental radioactivity is constantly increasing due to more stringent regulations and after the new prospective introduction of nuclear energy in european countries. In Italy the Rad-Monitor project has focused its attention in studying the radioactivity by applying several γ-ray spectroscopy measuring techniques, both by means of high efficiency and purity germanium detectors on field collected samples [1] and by using in situ and airborne instruments [2].

The AGRS (Airborne Gamma Ray Survey) method has been found to be a powerful technique with respect to in-situ measurements since it is faster and it allows to monitor large areas. This of course put a constraint on the spatial resolution of the method, which averages the signal over the area covered by the time slice (typically of the order of 0.1 km^2).

Inside the Rad-Monitor project a new AGRS system has been developed. The system is designed to follow the IAEA prescriptions [3], improving the compactness and reducing the weight in order to be carried by several types of flying vehicles.

A first test of the instrumentations has been performed on the Elba Island. Thanks to the high number of different type of rocks in a relative small area, the Elba is an ideal case to verify the accuracy of the apparatus. It is also ideal case for checking the analysis procedures that accounts for the null contribution of the coast water surface to the signal. Furthermore the planned path allows to fly over water surface at the beginning and at the end of the survey giving the possibility to determine quite precisely the radon correction.

THE FLIGHT ON THE ELBA ISLAND

The flight path has been chosen following geological prescriptions and constrained by the morphological structure of the ground terrain. In the chart 1:10000, 73 formations are indicated. They are disposed mainly from north to south, so it was decided to flight from east to west in order to cross perpendicularly, as much as possible, the formations borders. The unique region not fully covered by the airborne survey was the top of Mt. Capanne, because to the adverse weather conditions occurring the day of flight. The flight lasted about 2.5 hours. The initial position (and the final one) was located near Tuscany coast, so we could exploit the opportunity to survey a water surface at the beginning (and at the end) of the measurements on the Elba Island. This makes more consistent and reliable the correction for the ^{222}Rn in air. The flight was performed at an average altitude of 100 m and at 100 km/h of speed. This brings to a mean transversal spatial resolution of 300 m.

SPECTRA ANALYSIS

The setup has been already described in a previous Annual Report [4] and we send back to that for details. The signal coming from each detector is acquired separately in list mode. The spectra are reconstructed by fixing a suited time interval. The main constraints on the chosen interval time are the traversal spatial resolution and the spectrum statistics. We have found that the optimal compromise was a value of 10 sec. The spectra were analyzed by using the Full Spectrum Analysis as written in [2]. In the FSA method the shape of the total spectrum is taken into account and is “unfolded” into spectra for the individual radionuclides (sensitive spectra) and a background spectrum, while the NNLS prevents possible non physical negative concentration results produced by the standard χ^2 minimization [2].

Since the spectra analysis gives concentration values referred to the spectra acquired at the flight altitude, this has to be related to the effective concentrations on the ground surface. The measured values must be corrected for the γ attenuation in air, the ground topography, and the radon air contribution to the eU signal. It has to be noted that since the ^{238}U and the ^{232}Th are not γ-ray emitters their concentrations (eU and eTh) are evaluated detecting the γ-ray produced by ^{214}Bi and ^{208}Tl respectively. The assumption of secular equilibrium of the decay chains is required in order to use this approach. Since the calibration of the AGRS setup was performed by acquiring spectra in selected sites at 0 m altitude [2], the distortions in the spectra due to the absorption and γ scattering in air need to

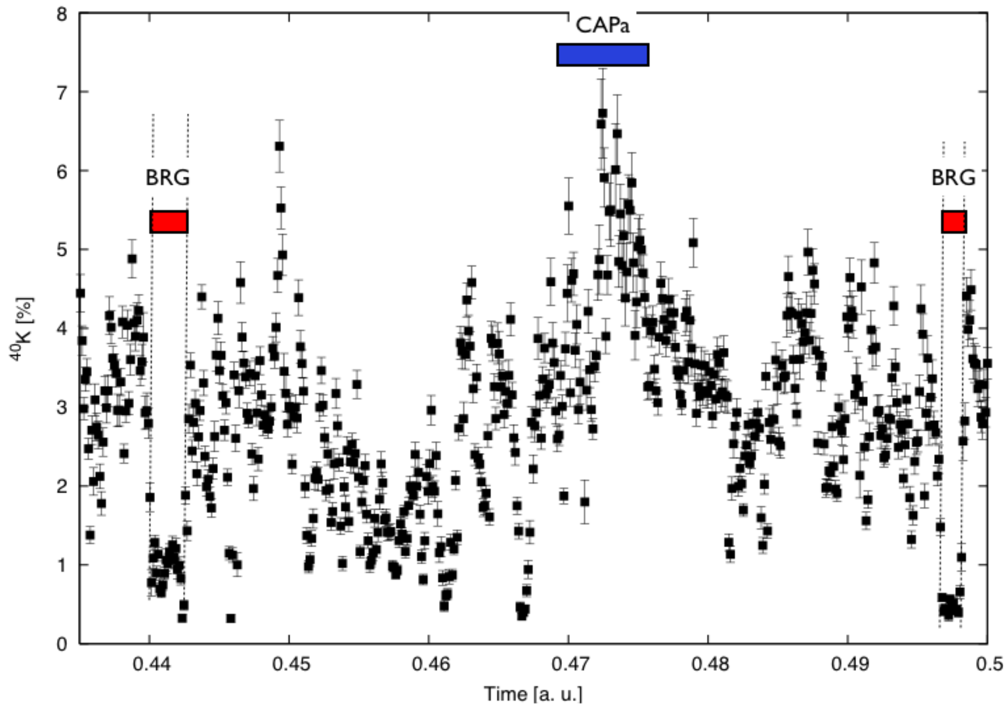

Fig. 1. The measured abundance of ^{40}K with respect the flying time (in arbitrary units). In the figure two different formations crossed by the AGRS system are underlined (BRG in red and CAPa in blue). The reported errors are only the statistical ones.

be taken into account. To that purpose a Mt. Carlo code based on GEANT4 [5] has been developed and the effect has been evaluated as a 15% contribution to the final systematic uncertainties. Further studies on these features are required to reduce this value.

SUMMARY AND CONCLUSIONS

The concentrations obtained in the surveyed area are summarized in Fig. 1 for the ^{40}K on a fraction of the Elba flight. The other radio elements shown a similar behaviour. Two of the 73 formation are underlined in the graph. The CAPa formation is the Monzogranito di Mt. Capanne and it covers the almost part of the Mt. Capanne. Monzogranites (MGr) are biotite granite rocks that are considered to be the final fractionation product of magma. We were not able to flight over the Mt. Capanne peak due to the adverse weather conditions and the measurements on this area are also affected by the influence of the costal formations which are connected to CAPa. The BRG formation is made of basalts rocks with weak content of radioactive elements. During the flight the system crossed this formation in two different areas with the same content of potassium. The sharp boundaries of the two regions reflect the spatial resolution of the system (each point is separated by 10 seconds which correspond to about 300 m).

The systematic uncertainty for all elements are comprised in 20% and 40% with a higher variability of the eU concentration due to the radon correction, whereas it is relevant only for very small abundances of eU. Despite this level of uncertainties, the results are already acceptable for the purposes of this type of studies, further test flight are planned to increase the accuracy of the corrections and to reduce the systematics below 15%.

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