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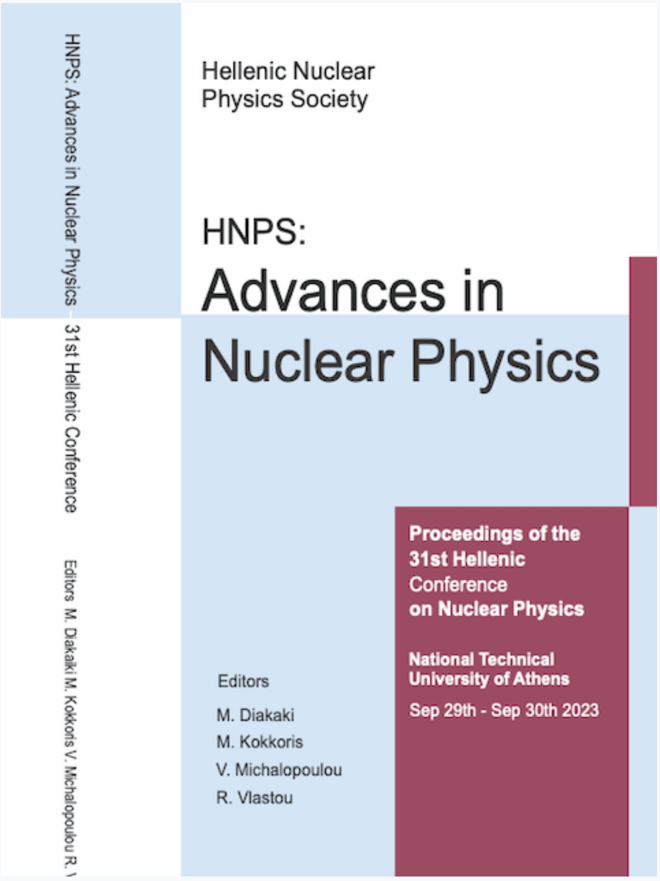

Validation and Testing of Novel Underwater Sensors at the Hydrothermal Vent Field of Milos

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Validation and Testing of Novel Underwater Sensors at the Hydrothermal Vent Field of Milos

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Abstract A prototype mobile underwater CdZnTe-based spectrometer was tested under realistic environmental conditions under the scope of the *RAMONES* Research Programme. Field measurements took place on the island of Milos, which is characterized by the extended hydrothermal vents. A combination of static and dynamic *in situ* measurements along with analysis of sand and sediment samples, allowed for evaluation of the instrument and will guide its ongoing optimization. Furthermore, a prototype Risk Information System is being developed, allowing easy access for the local stakeholders and scientific community to radioactivity data collected from the instruments of *RAMONES*.

Keywords marine radioactivity, CdZnTe spectrometer, hydrothermal vent field, marine sample analysis, risk information system

INTRODUCTION

Radioactivity monitoring in the marine environment is an extremely challenging task due to the harsh environmental conditions prevailing in the ocean and the difficulties arising during the detection process due to the attenuation induced by water. *RAMONES* (Radioactivity Monitoring in Ocean Ecosystems) [1] is a highly ambitious FET Proactive Research Programme aiming to overcome current limitations and provide *in situ*, in near-real time and long-term radioactivity monitoring at the most remote and inhospitable aquatic environments. To that extend, a fleet of novel underwater radioactivity sensors is currently being under development and testing.

One particularly prototype class of instruments includes the utilization of mobile CdZnTe (CZT)-based spectrometers aboard autonomous underwater gliders (AUG). These instruments are called *γSniffers* and as their name implies, their goal is to perform extended surveys in the water column aiming to identify levels of radioactivity above the natural background in the water. The *γSniffers* along with all other radiations sensors developed by *RAMONES* need to be characterized before final deployment, to investigate their response under a variety of scenarios. Experiments in the lab combined with Monte Carlo simulations have provided us with a solid baseline regarding the response of the sensors. However, to test the instruments under realistic environmental conditions, field measurements are necessary to optimize their operation schemes before the final deployment.

The *γSniffers* were first tested in the island of Milos in Greece. Milos belongs to the Hellenic Volcanic Arc (HVA), presenting extended hydrothermal activity and hence expected elevated levels of radioactivity mainly due to emission of ^{222}Rn and its progenies. As a result, this vent field is an ideal location to evaluate the response of the sensors, and their ability for elevated activity localization underwater. Static and dynamic *in situ* measurements were performed in selected underwater areas of the island. Additionally, samples of beach sand and sediment were collected and measured in a high-resolution spectrometer in the lab. Finally, results from the field measurements now feed a prototype Risk Information System developed by our *RAMONES* partners.

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EXPERIMENTAL DETAILS

In situ measurements

Each *γSniffer* carries a mobile CdZnTe-based spectrometer equipped with a crystal of total volume of 4 cm^3. An extensive characterization of the sensor has been accomplished via experiments in the lab and Monte Carlo simulations. More specifically, the necessary energy calibration has been performed and the capabilities of the instrument in underwater operation have been deduced. Throughout the tests in Milos, the sensor was encapsulated inside a waterproof aluminum housing suitable for deep-sea operation, ensuring the integrity and stability of the instrument (Fig. 1).

Figure 1. *The γSniffer along with its waterproof housing, during the field measurements in Milos*

At first, static *in situ* measurements were performed at various locations on the island. The goal was twofold: to ensure the stable operation of the sensor, but also to acquire the background radioactivity levels existing on each location. Additionally, the response of the sensor in realistic scenarios was examined in the field.

Measurements of samples

Samples of beach sand and sediment were collected from various coastal areas of Milos. Each sample was dried, grain filtered and weighed to be measured in a fully shielded HPGe detector in the lab (Fig. 2). All measurements lasted approximately 24 hours to ensure adequate statistics. Finally, cross-check was performed with reference materials, measured under the same setup geometry.

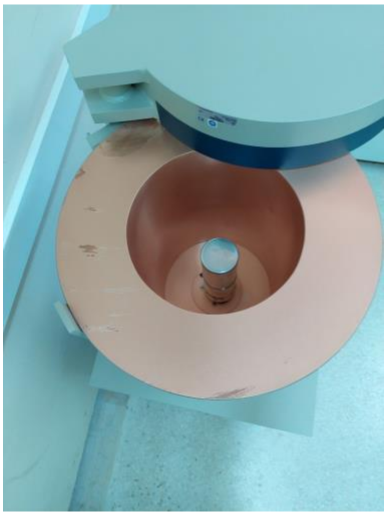

Figure 2. *The fully shielded HPGe detector used for sample analysis*

RESULTS AND DISCUSSION

Results acquired from the static *in situ* measurements were time normalized and are presented in Fig. 3. These results are preliminary and still under investigation. Variations appearing between measurements are inherent of the radioactivity levels existing on each location. The energy range was selected (0–600 keV) appropriately, to underline the variation of the Compton continuum, which is dominant in underwater measurements especially when instruments with small detection volumes are used.

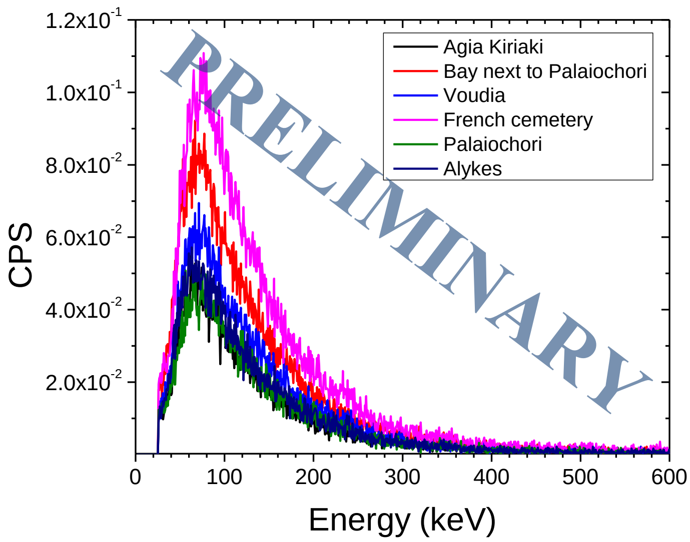

Figure 3. *Count rate registered from various locations of Milos*

Sample analysis was performed with the aid of reference materials [2] of known specific activity for various isotopes of interest. Regarding the evaluation of ^{226}Ra, the photopeak at 186.2 keV was studied and the corresponding specific activities of selected samples are illustrated in Fig. 4.

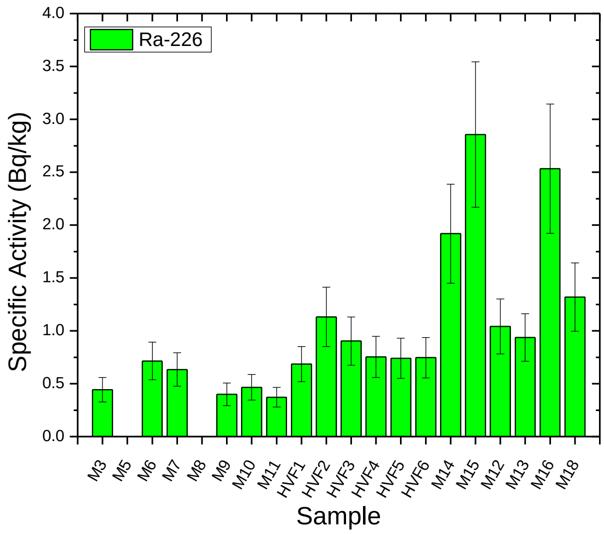

Figure 4. *Specific activity of ^{226}Ra calculated for various sand and sediment samples from Milos*

Findings from the sample analysis will feed the geological characterization of the studied areas, as well as benchmark the *in situ* measurements towards establishing a correlation between the radioactivity levels and the response of the *γSniffer*.

Moreover, a prototype Risk Information System (RIS) called *POIS²ON* (PrOtotype Information System for SOcioecoNomic stakeholders) has been developed by our *RAMONES* colleagues. After every deployment of *RAMONES* instruments or sample collection, the database of *POIS²ON* will be enriched with information including the acquired spectra, activity and dose calculations. Each dataset will be integrated with geospatial information to provide better geographical coverage, enhancing the overall analysis. Accordingly, risk indices will be presented and illustrated using heat map visualization techniques (see Fig. 5), to provide clear guidance to interested local stakeholders, the scientific community and the public. As a result, strategy planning towards risk mitigation will be based on actual and densely collected radioactivity data from the marine environment.

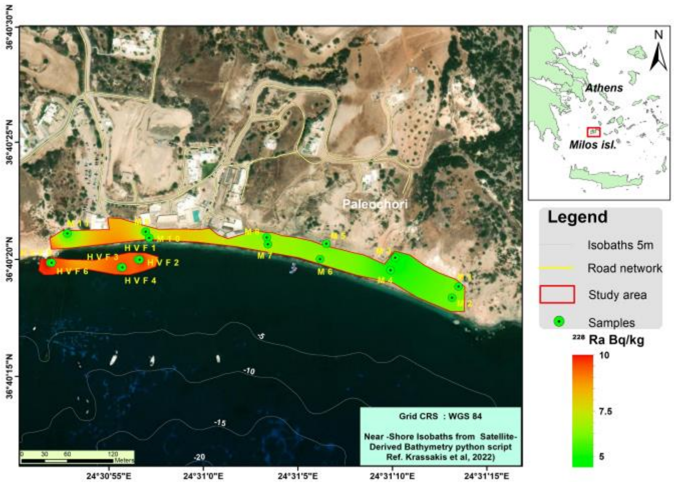

Figure 5. *Radioactivity map presenting the concentration of ^{228}Ra in Palaiochori, Milos. The green areas depict lower concentrations, where the red gradient represents the higher concentration of ^{228}Ra in Bq/kg.*

CONCLUSIONS

A prototype class of mobile underwater spectrometers was tested under realistic environmental conditions in the island of Milos. The hydrothermal activity existing on Milos allowed for a wide set of radioactivity measurements to be performed. Static and dynamic *in situ* measurements were carried out in strategically selected marine locations. The sensor's response during these measurements, provided useful information to optimize the operational schemes and protocols before its final deployment. Complementary measurements of sand and sediment samples will contribute to the optimization procedure, acting as a benchmark. Lastly, through a prototype Risk Information System (*POIS²ON*), radioactivity data retrieved after every deployment of the *RAMONES*' sensors will be available online for all interested parts.

Acknowledgments

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References

[1] EU H2020 FET Proactive RAMONES, url: https://cordis.europa.eu/project/id/101017808
[2] Z. Radecki et al., IAEA (2000), url: https://nucleus.iaea.org/sites/ReferenceMaterials/Shared