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ICP MS measurements of ultra low-level radioactivity in solid material and comparison with γ-spectrometry within the CUPID experiment

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Content

CUPID (ArXiv:1504.03612v1) is a proposed future ton-scale bolometric 0νDBD experiment that will be built on the experience gained in CUORE and LUCIFER, both currently installed underground at the Gran Sasso Laboratory in Italy. CUPID eventually aims at a sensitivity for the effective Majorana neutrino mass on the order of 10 meV, covering entirely the inverted hierarchy region of the neutrino mass pattern. This ambitious objective poses a set of very demanding technical challenges, among them a strong reduction of the background, which could allow in the best case to have no background event in the region of interest for the whole lifetime of the experiment. Common sources of background include cosmic rays, the environmental radioactivity surrounding the detector and radioactive contaminations naturally present in the materials used to build the detector itself. The operation of the experiment in the underground laboratory and the use of suitable shielding around the detector will suppress the cosmic ray flux and the environmental radioactivity. A strict selection of ultra-pure materials is fundamental for the construction of the experiment. Extremely sensitive analytical techniques, such as alpha and gamma spectroscopy, neutron activation analysis (NAA) and inductively coupled plasma mass spectrometry (ICP MS) are used for the selection of sufficiently radiopure materials. However, the actual detection limits for naturally occurring radio-contaminants achievable with these analytical techniques often translate into potentially dangerous count rates for the CUPID experiment. For this reason, an improvement of the currently attained sensitivities is mandatory for the selection of materials to be used in CUPID. Pre-concentration techniques typically allow an increase of the sensitivities, especially when coupled with analytical techniques such as mass spectrometry. In this work, ICP MS measurements of the long-lived radio-nuclides Th and U at ultra-trace levels in copper, which is envisaged to be one of the CUPID detector materials, are presented. A dedicated study has been carried out in order to develop an analytical procedure able to maximize the sensitivity for the quantification of Th and U in that matrix. The chemical separation and pre-concentration of the analytes was performed using chromatographic extraction techniques. Different resins have been explored. Best efficiency and lowest background were obtained with two of these resins, which allowed to reach detection limits of the order of 10ˆ(-13) g g-1. Together with pre-concentration of the analytes, also a reduction of the instrumental background was needed to further improve detection limits. For this purpose, a careful cleaning of all the vials involved in the sample preparation procedure and a preliminary rinsing of the resins themselves were performed. Ultra-pure grade reagents were used and all operations were carried out in an ISO6 class cleanroom. The obtained results, which represent a significant goal in the measurement of trace elements in solid materials, are reported in this work. Moreover, the ICP MS technique allowed a depth profile contamination study of the copper samples using selective and controlled dissolution steps of the copper samples.

About the Presenter

I am currently a postdoc at the INFN-Gran Sasso National Laboratory in Italy. I have a Master Degree in Chemistry, obtained with honors at the University of L'Aquila (Italy) in 2010, and a Ph.D. in Physics, successfully completed in March 2016 at the University of L'Aquila (Italy). I have a solid experience in isotope and trace element mass spectrometric analysis, including analyses on a quadrupole ICP-MS, high resolution ICP-MS and TIMS. My work mainly focuses on the detection of low-level radioactivity through the measurement of long-lived radionuclide traces in several samples types and on the development of new analytical methods for the improvement of detection limits. In 2012 I have been working as a guest research collaborator at the Chemistry

Department of the Brookhaven National Laboratory. I am co-author of several published papers on international scientific journals and I attended several international conferences on mass spectrometry and radio-analytical chemistry.

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