Atom Counting of Noble Gas Radioisotopes with Accelerators: Sucesses and Limitations

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Accelerator Mass Spectrometry (AMS) evolved primarily around tandem accelerators because ^{14}N does not form negative ions, which was the key for the detection of ^{14}C [1,2]. For a few other radioisotopes of interest (^{26}Al, ^{41}Ca, ^{129}I), a similar suppression of stable isobars is possible (no $^{26}Mg^{-}$, $^{41}KH_3^{-}$, $^{129}Xe^{-}$) . Since most elements form negative ions, almost all AMS facility (~100 world-wide) are based on tandem accelerators, and AMS became a versatile tool to measure minute traces of a variety of long-lived radioisotopes in the environment at large. However for radioisotopes where the stable isobar also forms negative ions, an isobar separation has to be achieved after the accelerator.

^{81}Kr: Stable-isobar suppression becomes particularly difficult for AMS of noble gas radioisotopes. Nobel gases do not form stable negative ions, and consequently accelerators with positive ions have to be used [3]. Since any element can form positive ions, a selective suppression of stable isobars in most ion sources is not possible (except, perhaps, in laser resonance ionization ion sources). But high energy and special detection techniques allow an isobar separation. This led to the first detection of ^{81}Kr with the Superconducting Cyclotron at MSU after separation of fully-stripped $^{81}Kr^{36+}$ ions at 3.6 GeV from the $^{81}Br^{35+}$ background in a spectrograph. With this method $^{81}Kr/Kr$ ratios in the 10^{-13} range were measured for the first time in groundwater samples from the Great Artesian Basin of Australia [4, 5].

^{39}Ar: Measurements of ^{39}Ar were performed at the ATLAS linear accelerator at Argonne, were a separation from a strong ^{39}K background was achieved at 232 MeV with the gas-filled-spectrograph technique. Isotopic ratios of $^{39}Ar/Ar$ in the range of 10^{-16} were measured for some ocean water samples from the Southern Atlantic ventilation experiment (SAVE) [6]. Although a sensitivity level of $^{39}Ar/Ar$ ~$4x10^{-17}$ was achieved, there was interest to push this level further down by at least an order of magnitude in order to test argon from wells with a low ^{39}Ar content. This is of interest for dark matter searches with large liquid-argon detectors [7]. Extensive experiments were therefore performed to reduce the potassium contamination in the electron-cyclotron-resonance ion source of ATLAS – with no avail [8].

In this talk some relevant aspects of AMS of noble gas radioisotopes will be summarized, discussing both successes and limitations, and possible future developments.

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