

Who needs chemistry when you have lasers and a tandem accelerator?

ROBIN GOLSER¹, OSCAR MARCHHART¹, MARTIN MARTSCHINI¹, MARCO MICHEL², ERIK STRUB², ALEXANDER WIESER¹ AND SILKE MERCHEL¹

¹University of Vienna, Faculty of Physics, Isotope Physics

²University of Cologne, Division of Nuclear Chemistry

Presenting Author: silke.merchel@univie.ac.at

For many years, cosmogenic nuclides such as ¹⁰Be, ¹⁴C, ²⁶Al and ³⁶Cl are routinely determined by accelerator mass spectrometry (AMS) to quantify and date processes in Earth, Environmental and Planetary Sciences. More recently, AMS was successfully performed to measure long-lived radionuclides of (mainly) anthropogenic sources, such as ⁴¹Ca, ⁵⁵Fe, ⁹⁰Sr, ⁹⁹Tc, ¹²⁹I, ^{135/137}Cs, ^{233/236}U, and ²³⁷Np. Analytically most challenging are radionuclides (⁶⁰Fe, ¹⁸²Hf, ²⁴⁴Pu) with isotopic abundances as low as 10⁻¹⁶. Those nuclides are the remains from nuclear stellar processes and had been stored in terrestrial archives such as marine deep-sea sediments.

Applications are very diverse: Starting from cosmochemistry to reconstruct irradiation conditions of meteorites and the constancy of the cosmic radiation itself over geomorphology and oceanography to study climate and environmental changes to finally nuclear decommissioning and waste storage.

Common to all, however, is the tedious radiochemical separation to deplete matrices and isobars, which was usually a prerequisite for AMS hindering fast and reasonable analysis until recently. Now, the world-wide unique ion-laser interaction mass spectrometry (ILIAMS) system developed at the Vienna Environmental Research Accelerator (VERA)^[1] provides isobar suppression by up to fourteen orders of magnitude.

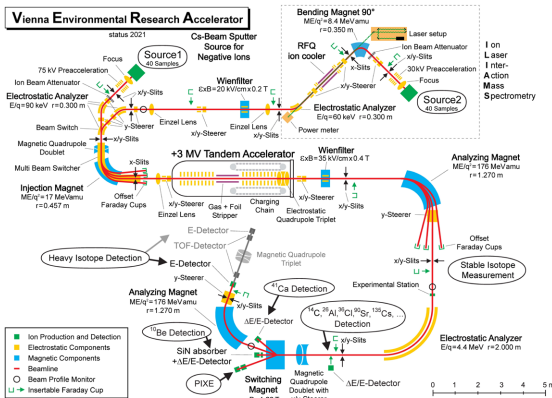
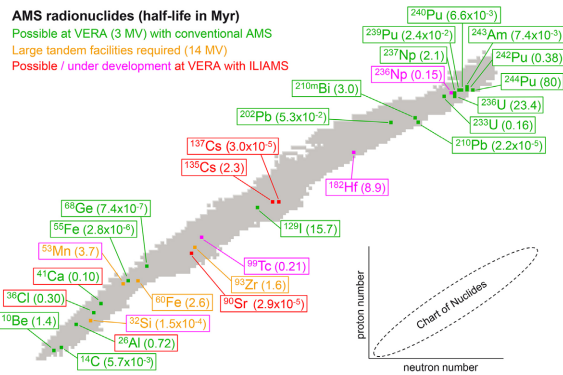
Hence, ILIAMS-assisted AMS enables the direct detection of e.g., ²⁶Al/²⁷Al (~10⁻¹⁰) and ⁴¹Ca/⁴⁰Ca (~10⁻¹¹) in simply-crushed stony meteorites containing intrinsic ~1% Al and Ca. The presence of isobars, natively-abundant elements (15% Mg, 0.1% K), does not cause any analysis problem, making any radiochemical separation redundant.

We have also quantified ⁴¹Ca/⁴⁰Ca as low as 10⁻¹² – in the presence of 0.5% potassium – without any chemical treatment for concrete and simple HCl leaching for heavy concrete (baryte); both materials were earlier exposed to thermal neutrons in a nuclear reactor.

Additionally, first ²⁶Al/²⁷Al (~10⁻¹¹) tests on terrestrial quartz samples from high altitudes used for surface exposure dating look promising to set-up AMS as a pre-screening and sample selection method before starting tedious chemistry for more accurate results. When combined with a high-ion current output ion source, high-accuracy results without any chemistry might be within reach.

Acknowledgements: We thank B. Bookhagen, L. Ferrière, L. Frost and D. Heinlein for providing samples.

[1] Martschini et al., 2022, doi.org/10.1017/RDC.2021.73.



Vienna Environmental Research Accelerator status 2021. Legend: Green = Ion Production and Detection; Orange = Electrostatic Components; Blue = Magnetic Components; Red = Beamline; Yellow = Beam Profile Monitor; Purple = Inertial Faraday Cup.