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^{10}Be measurements at 220 kV terminal voltage

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The compact 0.3MV MILEA AMS facility was developed at ETH Zurich in collaboration with Ionplus AG, Switzerland, as an optimized low energy AMS system for the analysis of a series of long-lived radioisotopes such as ^{10}Be, ^{14}C, ^{26}Al, ^{41}Ca, ^{129}I and actinides. The MILEA facility is equipped with a vacuum insulated accelerator that is powered by a commercial solid state power supply (Heinzinger GmbH, Germany) and deploys a Helium gas stripper. On the low energy side, a magnet - electro static analyzer (ESA) pair provides an achromatic injection of a negative ion beam into the accelerator. A quadrupole triplet located subsequent to the accelerator allows for an optimal beam transport on the high energy side for different positive charge states q ∈ {1, 2, 3, 4, 5}.

^{10}Be is measured at ETH Zurich routinely on the MILEA facility at a terminal voltage of 220 kV since 2019. Despite the relatively low terminal voltage a high beam transmission through the accelerator of over 40% for the 2+ charge state is achieved. This is possible due to an unexpected increase of the Be^{2+} charge state yield to 43% at low stripping energies (< 250 keV), while the yield of B^{2+} is limited to about 20%. This results in a first Boron suppression directly by the charge exchange process. Further suppression of the isobar is achieved by a degrader foil technique that takes advantage of the higher stopping power of Boron compared to Beryllium. After passing a 75 nm silicon nitride foil, ^{10}B can be blocked after an ESA with a movable aperture. Angular and energy straggling that are introduced by the degrader foil limit the beam transport on the high energy side to 25%. Hence, the total transport efficiency (from the ion-source to the detector) equates to around 10%. Final ion identification is performed in a two anode ΔE-E$_R$ gas ionization chamber (GIC). The excellent separation provided by the GIC-detector allows for the selection of ^{10}Be with no significant additional losses. This setup achieves a normalized ^{10}Be / ^{9}Be blank value below 2×10^{-15} that is sufficient for common applications.

On the low energy side, the negative molecular BeO beam is selected for injection due to the higher extraction currents (of typically 6-10 μA) compared to atomic Be anions. However, the choice of injecting molecules into the stripper gas introduces an additional angular and energy spread to the beam. This is caused during the break-up process in the stripper gas when both former molecular constituents happen to be positively charged and consequentially repulse each other by coulomb force (coulomb explosion). This effect has a significant influence on the beam profile on the high energy side of the accelerator and required the degrader foil to be wider than expected to provide for sufficient spatial acceptance.

Finally, a dilution series of ^{10}Be standard solutions (Nishiizumi, 2022) is used to demonstrate the precision, stability and linearity of the system. Further, a new ETH Zurich in-house standard solution was prepared and calibrated that better represents the expected ^{10}Be / ^{9}Be ratios of typical user samples.

References

- Nishiizumi K. (2022). Preparation of new ^{10}Be and ^{26}Al AMS standard reference materials. Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, 530: 43–47.

Student Submission

No

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