Nuclear Instruments and Methods in Physics Research B xxx (2015) xxx–xxx

Contents lists available at ScienceDirect

Nuclear Instruments and Methods in Physics Research B

journal homepage: www.elsevier.com/locate/nimb

Development of the Accelerator Mass Spectrometry technology at the Comenius University in Bratislava

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ARTICLE INFO

Article history:
Received 25 November 2014
Received in revised form 7 February 2015
Accepted 8 February 2015
Available online xxxx

Keywords:
Accelerator Mass Spectrometry (AMS)
Pelletron
SNICS ion source
^{14}C line
CENTA

ABSTRACT

An Accelerator Mass Spectrometry (AMS) laboratory has been established at the Centre for Nuclear and Accelerator Technologies (CENTA) at the Comenius University in Bratislava comprising of a MC-SNICS ion source, 3 MV Pelletron tandem accelerator, and an analyzer of accelerated ions. The preparation of targets for ^{14}C and ^{129}I AMS measurements is described in detail. The development of AMS techniques for potassium, uranium and thorium analysis in radiopure materials required for ultra-low background underground experiments is briefly mentioned.

1. Introduction

Radiocarbon [1–5] and gamma-ray spectrometry laboratories [6–9] have been in operation at the Comenius University in Bratislava for over forty years focusing on investigations of long-lived cosmogenic radionuclides (e.g. in wine samples [10,11], in tree-rings [12,13], in lunar samples and meteorites [14–18]), as well as studying anthropogenic radionuclides in the environment [19,20]. We have been collaborating with several AMS laboratories on the analysis and evaluation of cosmogenic and anthropogenic radionuclides (^{10}Be, ^{14}C, ^{129}I, uranium and plutonium isotopes) in different matrices, including atmospheric aerosols, rainwater, seawater, and marine sediments [21–33]. Knowing the benefits of AMS for ultra low-level isotope analyses, it was therefore very natural that this technology has been of great interest for our future developments.

Following our previous experience and close cooperation with AMS laboratories in Tucson [34], Toronto [35] and Vienna [36] with a wide range of AMS applications, we have focused on a development of a tandem accelerator complex, which could cover a wide range of applications. A Centre for Nuclear and Accelerator Technologies (CENTA) has been established recently at the Comenius University in Bratislava (Slovakia) comprising of a state-of-the art tandem accelerator laboratory designed for ion beam studies and AMS [37]. In this paper, we focus on the laboratory design for AMS studies, preparation of targets, and discussion of the main characteristics.

2. Tandem accelerator laboratory

The present laboratory design for AMS was due to limited financial support restricted to an ion source for solid targets, the injection system, the 3 MV tandem accelerator, and a simple high energy analyzer with ion beam end station (Fig. 1). All available equipment was supplied by the National Electrostatics Corporation (NEC, Middleton, USA). The installation, which we expect to be completed in the near future, will include a fully equipped AMS line with 90°magnet, an electrostatic spectrometer, and the end of the line detector. A dedicated hall to accommodate the tandem accelerator laboratory has been built at the Comenius University campus at Mlynská dolina. The hall design separates the AMS line (the large magnet will be placed just after the Pelletron) from the ion beam channels (which will be shifted together with the switching magnet into a bunker covered by soil), enabling work in different radiation environments (Fig. 1). A detail description of the tandem accelerator laboratory is given in [37], here we present only the main characteristics.

The MC-SNICS source (MultiCathode Source of Negative Ions by Cesium Sputtering) to be used in AMS measurements has a wheel

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http://dx.doi.org/10.1016/j.nimb.2015.02.021
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Please cite this article in press as: P.P. Povinec et al., Development of the Accelerator Mass Spectrometry technology at the Comenius University in Bratislava, Nucl. Instr. Meth. B (2015), http://dx.doi.org/10.1016/j.nimb.2015.02.021

accommodating up to 40 solid targets [38]. A wide range of elements (from lithium to transuranics) can be used in the SNICS ion source (Figs. 1 and 2). After the production and extraction of ions from the SNICS source, the first E/q separation of the ions is made by an electrostatic analyzer (ESA) with electrodes of radius 300 mm, mounted on a rotatable platform. The momentum analysis (ME/q^2) and separation of ions before acceleration in the Pelletron is made by a double focusing 90° magnet with bending radius of 0.4572 m. The mass resolution of the injection magnet is $m/\Delta m = 305$. After the proper mass is selected, set of slits is used for parameterization of the beam, and a Faraday cup is used for measurements of ion currents. Negative ions are then injected into the tandem accelerator. The 3 MV tandem electrostatic accelerator (NEC Model 9SDH-2 Pelletron) [39] is used for accelerating ions over a broad range of energies (Figs. 1 and 2). The terminal has a nitrogen gas stripping system. After acceleration, ions are analyzed by the switching magnet ($ME/Z^2 = 300$ amu-MeV @ ± 15°), which is equipped with seven ports at ±45°, ±30°, ±15°, and 0° with respect to the accelerator. The beam line at +45° is currently equipped with slits, *X–Y* electromagnetic steerers, Faraday cups for current measurements and with beam profile monitor. A dedicated beam line for AMS analysis consisting of a 90° magnet ($ME/Z^2 = 170$ amu-MeV), will be installed soon just after the Pelletron, followed by an electrostatic analyzer, and the end of the line detector.

The first AMS studies at the CENTA laboratory focused on transmission characteristics of accelerated Be ions with different energy and charge states, and varying gas pressure in the gas stripper of the Pelletron [37]. As the AMS line at the CENTA laboratory does not yet include a fully capable analyzing system, the possibility of measuring ^{10}Be using only a switching magnet as the ion analyzer was tested. A detail description of the method is presented in [37], here we mention only that even with a small switching magnet a good separation of $^{10}Be^{2+}$ and $^{9}Be^{3+}$ ions can be obtained. A detection limit for $^{10}Be/^{9}Be$ of the order of 10^{-12} was achieved, which was mainly limited by scattering of $^{9}Be^{2+}$ ions (energy of 7.059 MeV) on residual gas inside the switching magnet.

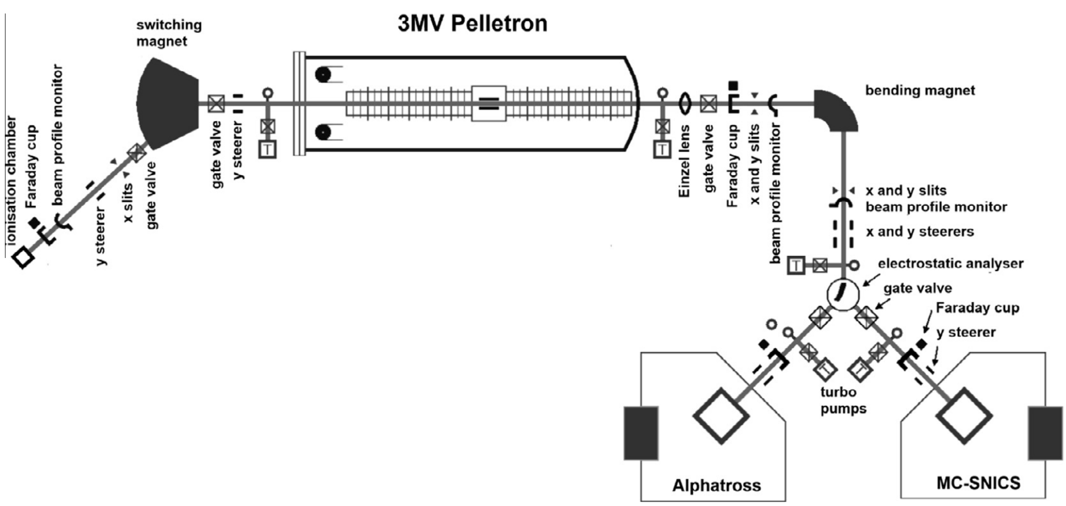

Fig. 1. Scheme of the tandem accelerator laboratory used for AMS measurements.

Fig. 2. Photos of the main parts of the tandem laboratory.

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