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A new AMS facility in Mexico

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ABSTRACT

A new Accelerator Mass Spectrometry system has been installed at the Institute of Physics of the National Autonomous University of Mexico (UNAM). A sample preparation chemistry laboratory equipped with computer controlled graphitization equipment (AGEIII) has also been established. Together both facilities constitute the LEMA (Laboratorio de Espectrometría de Masas con Aceleradores) first of its kind in Mexico. High sensitivity characterization of the concentration in a sample of ^{14}C as well as ^{10}Be, ^{26}Al, ^{129}I and Pu are now possible. Since the demand for ^{14}C dating is far more abundant, a data analysis program was developed in the cross-platform programming language Python in order to calculate radiocarbon age. Results from installation, acceptance tests and the first results of ^{14}C analyses of reference materials prepared in our own facility are presented.

1. Introduction

The creation of the Accelerator Mass Spectrometry Laboratory (LEMA) was approved in September 2010, under the auspices and funding of the National Council of Science (CONACyT) and the National Autonomous University of Mexico (UNAM). In April 2011, the Institute of Physics (IFUNAM) commissioned the fabrication of an AMS system based in a 1.0 MV Tandetron from High Voltage Engineering Europe, The Nederlands.

This new system expands the experimental capabilities available at IFUNAM which has the largest accelerator facilities in Mexico. Basic and applied research started at IFUNAM in 1953 when a HVECO 2 MV Van de Graaff model AN2000 was acquired, followed by a HVECO 0.7 MV model AN700 in 1972, a HVECO 5.5 MV Van de Graaff model CN in 1988 and a 9DSH 3 MV NEC Pelletron in 1996. The new AMS facility based in a 1MV Tandetron model 4110Bo-AMS will make now possible the analysis of ^{14}C, ^{26}Al, ^{10}Be, ^{129}I and $^{239,240,242}Pu$.

This kind of systems has been installed in a number of laboratories around the world, but it is the first in Latin-America. AMS is planned to be used in fundamental and applied research in Physics, Chemistry, Geology, Geophysics, Archaeology, Environment, and Biomedical. The AMS installation includes a room for computer control, offices, and three laboratories: chemical pretreatment, graphitization for ^{14}C and one for sample preparation of the other isotopes.

In this work we present the basic description of the laboratory and its performances. We also present the test sample preparation methods and ^{14}C results of reference materials prepared in our facility.

1.1. System description

Fig 1 shows a schematic view of the HV-AMS system. The SO110-B Cs^+ sputtering ion source section for 50 solid cathodes has been recently updated [1].

It is a compact ion source with a shield, in such a way that it does not need to be protected by a high voltage insulating cage. The metal walls guarantee its operation in a virtually radiation free environment. To avoid cross-contamination the samples are stored in a carrousel (with 50 positions) and only the sample to be measured is transported by a bayonet into the ion source chamber. The low energy section includes a 90° analyzing magnet with a 100 Hz bouncer for fast sequential injection of isotopes of different mass into the accelerator. The "blanking" unit defines with ns precision the time allocated to measure one specific isotopic mass in the accelerator. Sequential injection makes possible the measurement of isotopes present in concentration ratios from 10^{-10} to 10^{-15} and has the advantage of the use of a neighbor stable intense beam as pilot to setup the system for the rare isotope. For Pu isotopes the simultaneous injection is preferred. Between the ion source and the bouncer sections, there is a rotable 54° electrostatic separator (ESA) that allows through only particles with same energy to charge ratio. The ESA can be turned around to receive a 2nd ion source. The Accelerator section has a 1 MV tandetron with Ar gas

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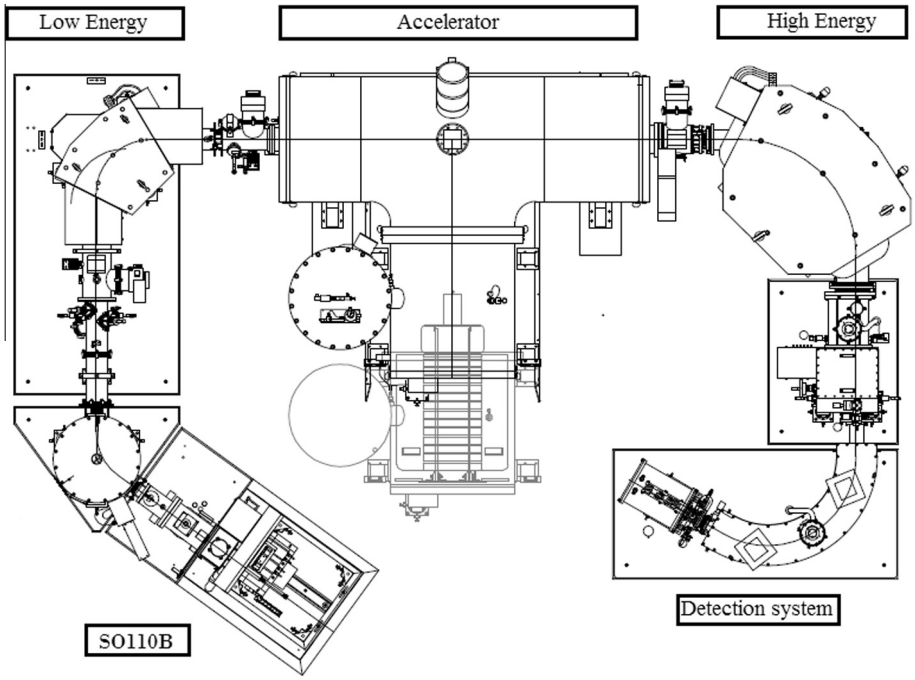

Fig. 1. Schematic of the new HV AMS. The main elements of the system include: the ion source SO110B; the low energy mass spectrometer with a 54° electrostatic analyzer and a 90° analyzing magnet with a bouncer; the 1MV Tandetron accelerator; the high energy mass spectrometer including a 90° analyzing magnet and faraday cups for the measurement of the stable isotopes ^{12}C and ^{13}C as well as ^{9}Be, ^{27}Al, ^{127}I; the detection system based in an electrostatic analyzer and a split anode gas ionization chamber (GIC).

stripper to destroy the interfering molecules. The High Energy (HE) mass spectrometer section has a 90° magnet (85 cm radius) followed by a segment with fixed and retractable Faraday cups. The fixed cup is dedicated for ^{12}C measurements and the movable cup is used for monitoring other stable isotopes (^{13}C, ^{9}Be, ^{27}Al, ^{127}I, etc.). The detection system includes a 120°-ESA and a detector (a split anode gas ionization chamber) to identify the rare isotopes ^{14}C, ^{10}Be, ^{26}Al, ^{129}I and Pu. With the exception of Pu isotopes, the ions are identified in two dimension $\Delta E - E_{res}$ maps. The ionization chamber, at 5–10 mbar isobutene pressure, is separated from the beam line, at 10^{-7} mbar, by a Si_3N_4 window (150 nm thickness).

2. Material and methods

2.1. Carbon samples

For ^{14}C acceptance tests, samples of NIST SRM 4990C Oxalic Acid (HOxII) were prepared in our own facility. To prepare the graphite, we acquired a commercial new Automatic Graphitization Equipment (AGEIII) from the Ion Beam Physics, Institute and ETH Zurich [2,3]. In this apparatus, an elemental analyzer (EA; Vario MICROCUBE Elementar) is coupled to a compact and fully automated graphitizer. The sample is weighted in a tin crucible and introduced into the EA, where is combusted at 950 °C. The CO_2 produced is separated from N_2, SO_2 and H_2O and transferred to the AGE by helium as carrier gas, where is trapped in a column of zeolite that replaces the use of lines and cryogenic traps. CO_2 is then transferred from the zeolite to each one of seven reactors, where the graphite is formed at 580 °C in the presence of H_2 and Fe powder catalyst. Routine preparation of 1 mg carbon is performed in a fast and reproducible way, but smaller samples (down to 30 μg) can also be analyzed. Death carbon blanks used in ^{14}C acceptance tests, were obtained from the Radiocarbon Accelerator Unit, Research Laboratory for Archaeology, Oxford.

2.2. Al, Be, I and Pu samples

Laboratory facilities to prepare samples for ^{26}Al, ^{10}Be, ^{129}I analysis are not ready, the standard materials for the acceptance tests (Al, Be, I) were kindly provided by the AMS group of ETH Zurich Switzerland (Arno Synal).

For Be analyses, the standard reference material Be-01-5-4 ($^{10}Be/^{9}Be$ ratio of 2.851×10^{-12} [4] and blanks (Al_3O_2), were mixed with Nb (1:3 Nb mol/mol ratio), and pressed in an Al cathode. A 75 nm Si_3N_4 degrader foil was placed before the HE electrostatic analyzer (ESA) in order to separate the ^{10}Be from its isobar ^{10}B.

The tests for ^{26}Al were performed with KN 01-4-1 reference material ($^{26}Al/^{27}Al$ ratio of 74.4×10^{-12} (±3.6%) [5]. Blanks and standards were mixed with copper (1:5 Cu w/w).

Standard reference material for iodine acceptance tests was D22, an ETH internal standard prepared by dilution of the NIST reference material SRM 4949B, with a $^{129}I/^{127}I$ ratio of $50.35 * 10^{-12}$ (±3.2%) [6]. Standards and blank (AgI) were mixed with silver (1:4 Ag w/w). The standards and blanks powders were pressed into aluminum or copper targets.

The Pu standard cathodes were provided by CNA Sevilla (Elena Chamizo).

3. Results

3.1. Performance tests

Performance tests were completed in June 2013 and the results are shown in Table 1. For each one the ^{14}C, ^{10}Be, ^{26}Al, ^{129}I and Pu isotopes, four cathodes assembled from the reference materials and their respective blanks, were analyzed. Each sample in the carrousel was measured nine times. Every measurement lasted 5 min subdivided in 10 cycles of 30 s. The average currents measured at the high energy side, are reported in Table 1. A transmission across the accelerator of approximately 41% was obtained for C^{2+}. For the