
Experiment Title   Test experiments and optimization of several new applications using AMS with 26Al

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Short presentation of the scientific project

Experiments for a PhD thesis entitled:

New applications and upgrading work at the Accelerator Mass Spectrometry (AMS) facility in Bucharest.

Experiment purpose: Test experiments and optimization of several new applications using AMS with 26Al.

Introduction

Aluminum is very important for the human kind since life evolved on our planet where aluminum is abundant however, only exists as an inert oxide both chemically and biologically. In the past century, humans learned to refine the metal from the oxide and we now today to use it in every from, for cooking pots, for underarm deodorants, for emulsifiers in infants' formula.

The biological effects of this active chemical element in humans was recently studied using 26Al. Natural aluminum is mono-isotopic (Table 1) but only 26Al is sufficiently long-lived for its practical use as tracer in experiments in living systems. However, it is known to have a deleterious effect on neurological systems, possibly causing some human diseases such as the Alzheimer’s disease.

Table 1 - The isotopes of aluminum

No.	Isotope mass number	Radioactive half-life
1	25	7.2 s
2	26	716 000 yr
3	27	Stable
4	28	2.3 min
5	29	6.6 min

Aluminum-26 is also used for a variety of geophysical and environmental applications in geophysics. 26Al observed in terrestrial and extraterrestrial matters provides one of the important clues to deciphering fossil records stored in the materials and allows investigation of their cosmic irradiation history.

26Al is produced in nature by the interaction of muons with 28Si (28Si(μ-,2n) 26Al), which is the most abundant isotope in the earth’s crust, except 16O. In order to investigate the secular variation of the cosmic radiation intensity 26Al must be searched in terrestrial silicate rock .

Quartz, which is a geologically abundant mineral, started recently to be used as one of the ideal tool for these studies. Using the AMS method is possible to measure the trace amount of cosmogenic radio-nuclides produced in terrestrial and extraterrestrial substances.

26Al usually cannot be measured by decay counting, due to the very long half-life (716,000 yr). As a result it is almost always measured by accelerator mass spectrometry (AMS) which has the ability to detect small amounts of 26Al, as 10-17 g.

Purpose of the experiment

The new developments achieved at AMS facility will be tested. We want to determine transmission of the pilot beam (ion source – AMS Faraday cup, ion source - detector), transmission efficiency of the machine and also the efficiency of the Wien filter.
The purpose in this experiment is to optimize the AMS facility in order to measure different, and very low concentrations of 26Al, in various applications.

The samples

The experiment implies measurements for a set of six samples. The samples are collected from an area with pronounced erosion (Zittergebirge - Germany).
AMS is a relative analysis method that requires standard samples. For these measurements we will use two sets of 26Al standards with 26Al/27Al ratio (10-10, 10-12).

The beam and the measurements

The AMS experiments are using the AMS injector.
One day is necessary to start up the experiment.
The experiment will use a 7 MV value of the terminal voltage and the vacuum must be better than 10-6 mbar.
In this experiment we use a pilot beam. We must spend a few hours to test which is the best sample material to use like a pilot beam.
It is well known that aluminum does not yield a prolific negative ion beam like other AMS elements such as chlorine, carbon and beryllium. Also targets made of solid aluminum metal (i.e. a sample that is machined from a solid rod of aluminum) yield a much higher negative ion beam than aluminum oxide (Al2O3).
To find out which sample material will yield the best 27Al current several compounds will be tested. The only constraint required for an aluminum compound to be suitable for the AMS target material is to be a stable solid and resistive to high temperature (about 400–5000C) as it occurs in the vacuum environment of a typical ion source.
In this initial search for new target materials, five different samples will be tested at the low energy side:
   commercially obtained aluminum oxide (Al2O3),
   aluminum carbide (Al4C3),
   aluminum diboride (AlB2),
   aluminum nitride (AlN),
   aluminum powder (Al) .
For these tests we need 5-6 hours.
Blank samples will be also used, besides the samples and standards, in order to determine the sensitivity limit.
For proper measurements of the samples is necessary to have 2 days. In this time we will measure the samples, standards and blank samples.
Since the quantity of interest is the isotope ratio, 26Al/27Al, it is also necessary to measure the intensity of the stable isotope.
In our system, this is done periodically by switching the first (low-energy) mass analysis to mass 27 and changing the terminal voltage, in order to give 27Al+ ions the same magnetic rigidity as the 26Al+ ions. In this way, the 27Al+ ions can be transmitted to a Faraday cup inserted (during the 27Al cycle) immediately in front of the ionization detector. The 27Al+ intensity is thus measured as an ion current.

We ask for a 4 days beam-time, in the period from 06.12.2010 to 10.12.2010.

Doctorand,
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Beam time request(unit=8 hours) : 12
Desired Period : 06.12.2010 to 10.12.2010

Desired beam properties

Type : AMS-beam
Energy(MeV) : 50 (7MV)
Intensity(p/nA) : 10
Vacuum Requests : 10-6torr

Special requirements for detectors, electronics,aquisition system
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Minimal information needed for the radiological risk evaluation:
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a)Source activity : no
b)Use of open sources : on
c)Estimate of the residual activity as a result of iradiation : no
d)Means of storage/transportation for iradiated targets : no