How to date a mummy
(with a low energy particle accelerator)

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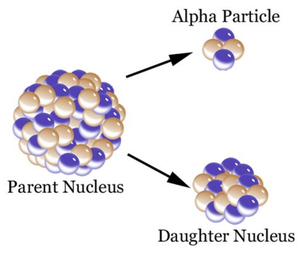
What is a radionuclide?

A radionuclide is a particle characterized by an unstable nucleus. After some time, it decays, i.e. transforms into another nucleus emitting ionizing radiation and reaching a state with more stability.



Why Accelerator Mass Spectrometry?

- It can find 1 radioactive atom on 1000000000000000 stable ones.
- The analysis is fast and needs a small quantity of samples.
- The machines can be small and... “cheap” :)

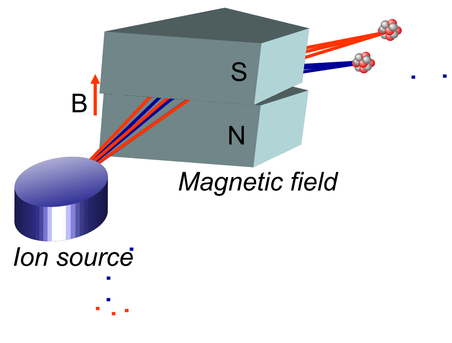
Radionuclide	Half life (years)	Isotopic ratio	Main applications
^{10}Be	$1.387 \cdot 10^{6}$	$^{10}Be/^{9}Be = 10^{-10}$	Geology
^{14}C	5370	$^{14}C/^{12}C = 10^{-12}$	Archeometry
^{236}U	$2.3 \cdot 10^{7}$	$^{236}U/^{238}U = 10^{-9}$	Environmental sciences

What is Accelerator Mass Spectrometry?

Accelerator Mass Spectrometry (AMS) is a technique adopted to measure the concentrations of very rare radionuclides with high precision.

It uses magnetic and electrostatic filters which select particles on their **masses** and **energies**.

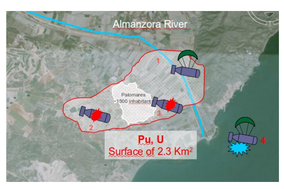
The importance of the accelerator is due to its ability to remove interferences and improve the precision of the measurements.



… AMS is like finding a beer drop in an Olympic swimming pool!

Artificial radioactivity: actinides

Thanks to the AMS technique, it's possible to know the consequences of the **accident in Palomares** or of the **pollution triggered by the Sellafield site** in the environment and in people's life.

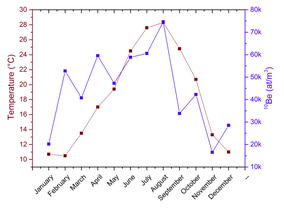


Carbon dating: ^{14}C

Measuring the ^{14}C present in a sample, we are able to determine its age.

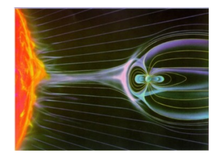
In this way, we can discover when the mummy of the Alps **Ötzi** or the mammut **Manfred** lived, or how old a **medieval manuscript** is.

A cosmogenic nuclide: ^{10}Be



^{10}Be distribution in the environment gives information of geological or paleogeological interest.

For example, we can find the **relationship between the temperature and the ^{10}Be** present in the atmosphere, or we can **date mountains**.

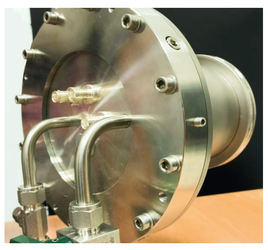


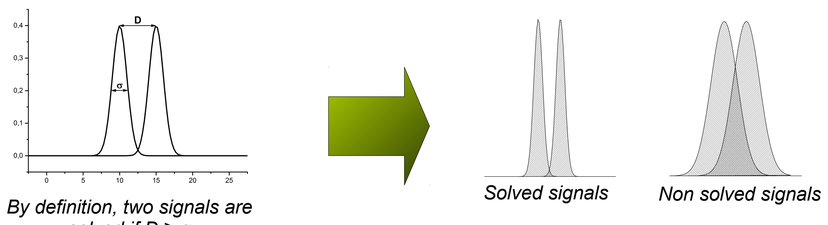
Keep calm and enjoy SARA

SARA is the 10 years old AMS facility hosted at the *Centro Nacional de Aceleradores*, in Seville.

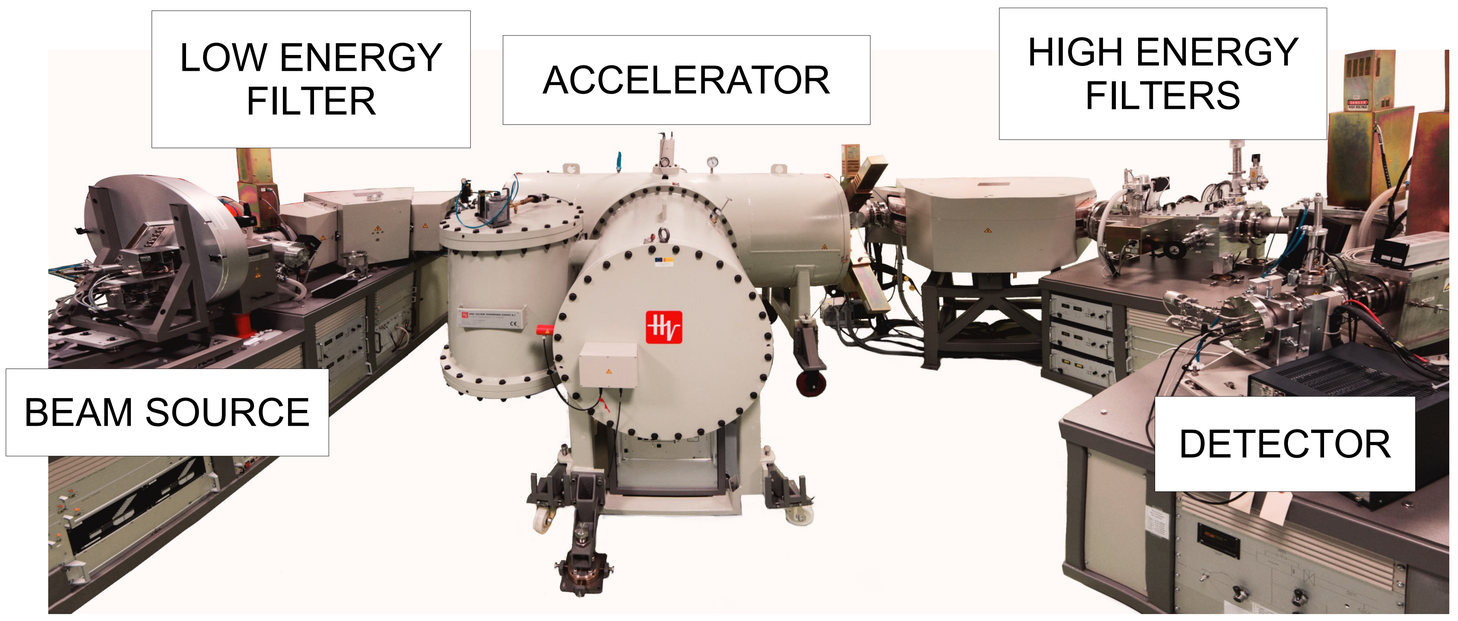
IMPROVING THE DETECTION

The detector has been recently substituted for a new one, and the **resolution** of the instrument improved specially for ^{10}Be.



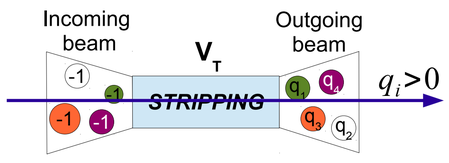


By definition, two signals are solved if D ≥ σ



IMPROVING THE TRANSMISSION

Inside of the accelerator, the beam passes through a gas-filled channel, so that molecules break up and interferences are eliminated.



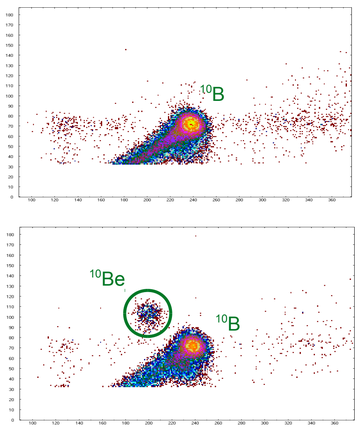
Changing the stripping gas from argon to helium, it was possible to obtain a better beam **transmission**.

Isotope	Charge state	Transmission (Ar stripper)	Transmission (He stripper)
Beryllium	+2	25%	35%
Aluminum	+3	13%	17%
Iodine	+3	10%	25%
Actinides	+3	13%	35%

BERYLLIUM? MIGHT ^{10}Be

^{10}Be is a problematic isotope to measure because of the presence of an abundant interference: ^{10}B. They can be separated making them pass through an ultra thin silicon nitride foil and selecting them by energy.

After the substitution of the stripping gas and the detector, beryllium spectra were acquired.



Blank and standard spectra in the new measurements conditions.

Blank sample: it is prepared in the lab so that it does not contain ^{10}Be. It is useful for evaluating the background.

Standard sample: it is prepared in the lab so that it contains a known amount of ^{10}Be. It is essential for identifying ^{10}Be and measuring the beam losses.