Optimization of Beryllium-10 Detection using a 1MV AMS System

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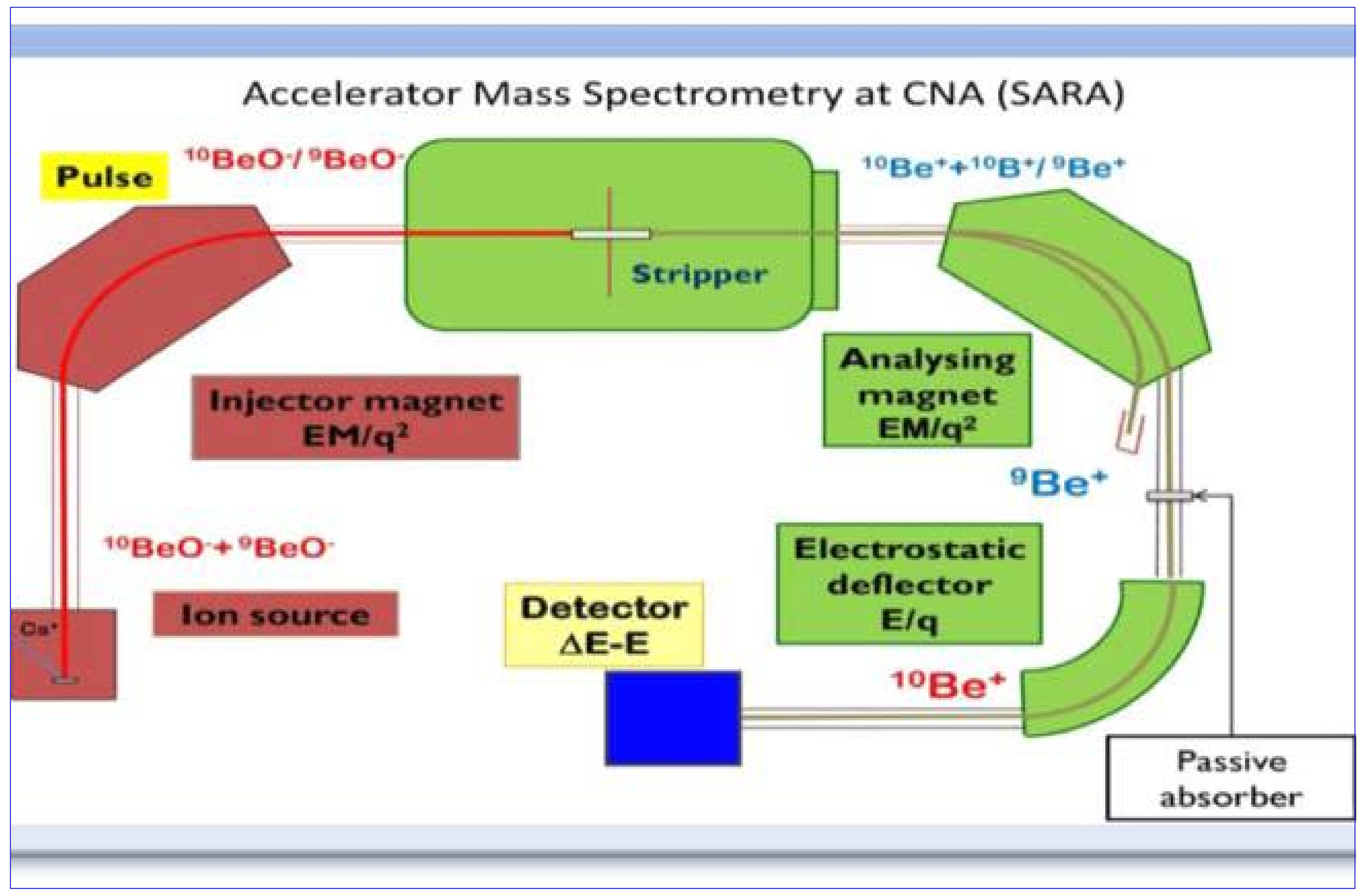
Introduction: Accelerator Mass Spectrometry (AMS)

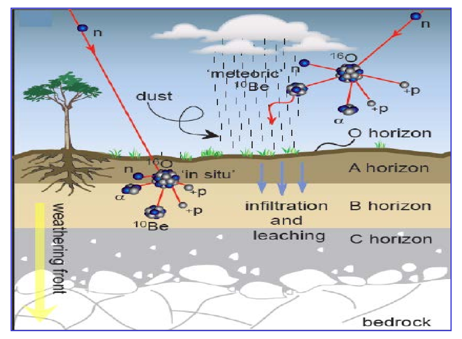
The Spanish Accelerator for Radionuclide Analysis (SARA) implements AMS, an accelerator technique, used to detect radioactive isotopes at extremely low levels by accelerating ions to extraordinary high kinetic energies before mass analysis. The special strength of AMS among the mass spectrometric methods is its power to separate a rare isotope from an abundant neighboring mass (´´abundance sensitivity ´´, e.g. ^{10}Be from ^{10}B).



Background & Motivation

Radionuclide of Interest:

Our study interest lies with ^{10}**Beryllium**. ^{10}**Be** is a long lived radioactive isotope (T1/2 = 1.51 My) present in natural samples at very low concentrations. It forms via high energy cosmic radiation interactions with target nuclei and is the second most common isotope that is used for radioactive dating purposes (after ^{14}C).



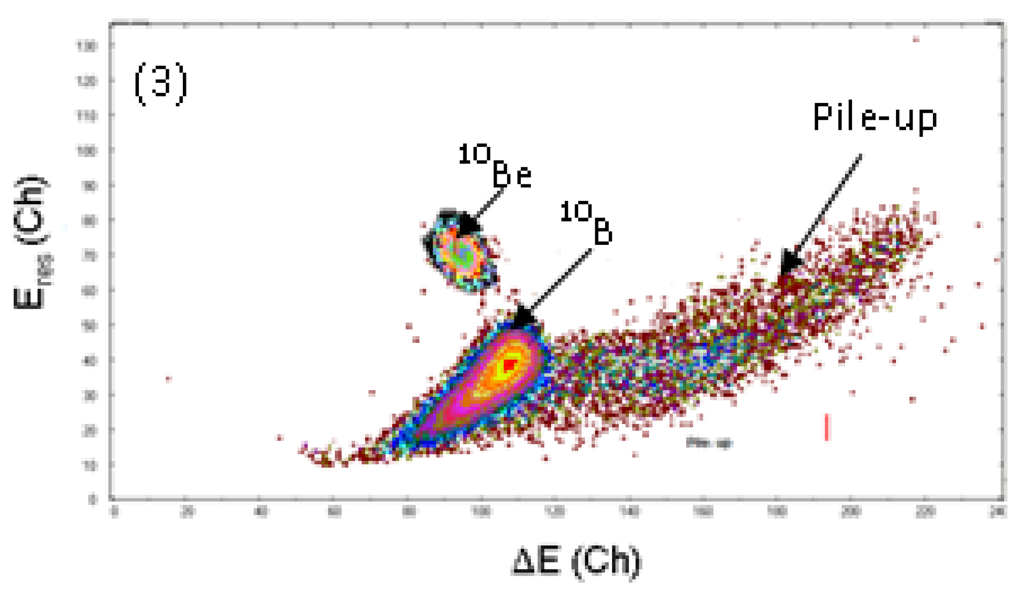
Applications
- Geology *(Exposure Age Dating, Tracing)*
- Paleomagnetism
- Nuclear Physics

Observation

^{10}Be is a challenging isotope to detect due to the presence of its stable isobar ^{10}B

Scientists often referred to the overwhelming presence of ^{10}B as the

'Dragon's Breath'



Strategy & Analysis

1. Speculation

Optimal ^{10}**Be** Detection is achievable with effective & maximum Suppression of ^{10}**B**

→ Multiple parameters contributing to total sensitivity for ^{10}**Be** Detection **.**

Sample **Magnet** **Detector**

2. Suppression Methods

→ Passive Absorber: ^{10}**Be** is injected as BeO

^{10}**B** is suppressed with the aid of a passive absorber.

A passive absorber is placed at the High Energy side.

Be and B loose different energies due to their respective stopping powers. Hence, they are partially separated by the Electrostatic Analyzer.

→ Sample Preparation: F-Be Compound

^{10}**B** is suppressed during the sample preparation process at a factor of 10^4.

No need to use a passive absorber: higher transmissions. However, extracted currents at the ion source are very low.

→ *Analyzing* Magnet

The Analyzing Magnet at the Spanish Accelerator for Radionuclide Analysis (SARA) reduces the amount of scattering from particles that contribute to noise at the detector site.

Low Energy Magnet	
ρ_0	40 cm
ε_1	26.65⁰
ε_2	30.65⁰
Θ	90⁰
$(EM/q^2)_{max}$	9.8 MeV·u/q²
r	680 mm/ (ΔM/M)

High Energy Magnet	
ρ_0	85 cm
ε_1	25.6⁰
ε_2	31⁰
Θ	90⁰
$(EM/q^2)_{max}$	73.92 MeV·u/q²
r	1300 mm/ (ΔM/M)

→ *Analyzing* Detector at CNA

Choice of Detector largely contributes to the sensitivity of ^{10}Be detection.

Ionization Chamber Specifications	
Detector at CNA	
Surface (mm)	8 X 8
Thickness (nm)	67
Window Material	Silicon Nitride

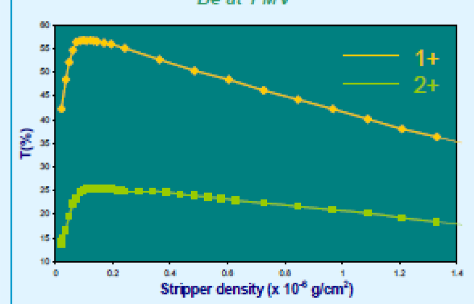
Measurements using AMS System at CNA

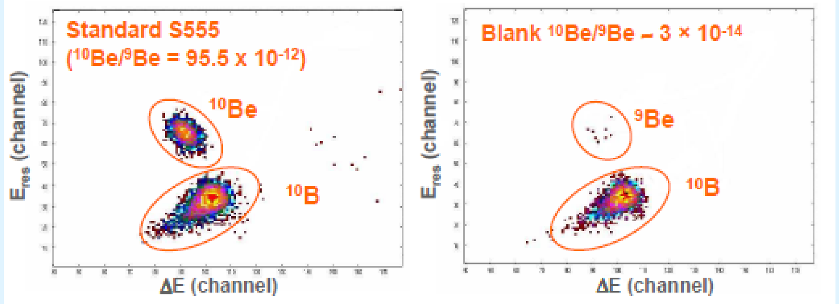
^{10}Be

BeO Method

TV	Charge state after stripping	Passive absorber (nm)	Charge state after absorber	Blank ^{10}Be/^{9}Be (× 10^{-14})	Total ^{10}Be transmission
1 MV	+1	150	+1	4.2 ± 1.8	~ 2.2 %
			+2	3.3 ± 1.1	~ 8 %

Transmission vs stripper pressure for ^{9}Be at 1 MV

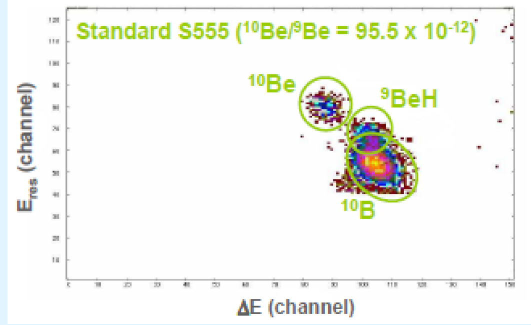




Ion	Low Energy Current (nA)
$^{9}BeO^{-}$ (+ Cu)	400-800
$^{9}BeO^{-}$ (+ Ag)	300-750
$^{9}BeF^{-}$ (+ Cu)	50-200

$BaBeF_4$ Method

Measured total ^{10}Be transmission by $BaBeF_4$ method (charge state 1+): **~41%**

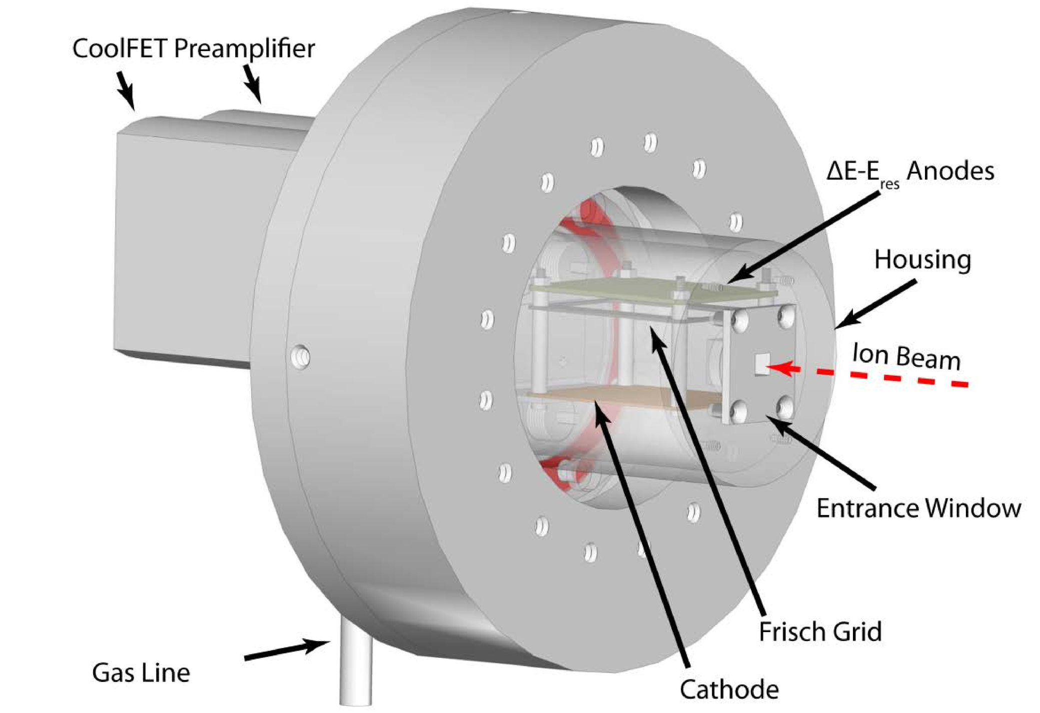


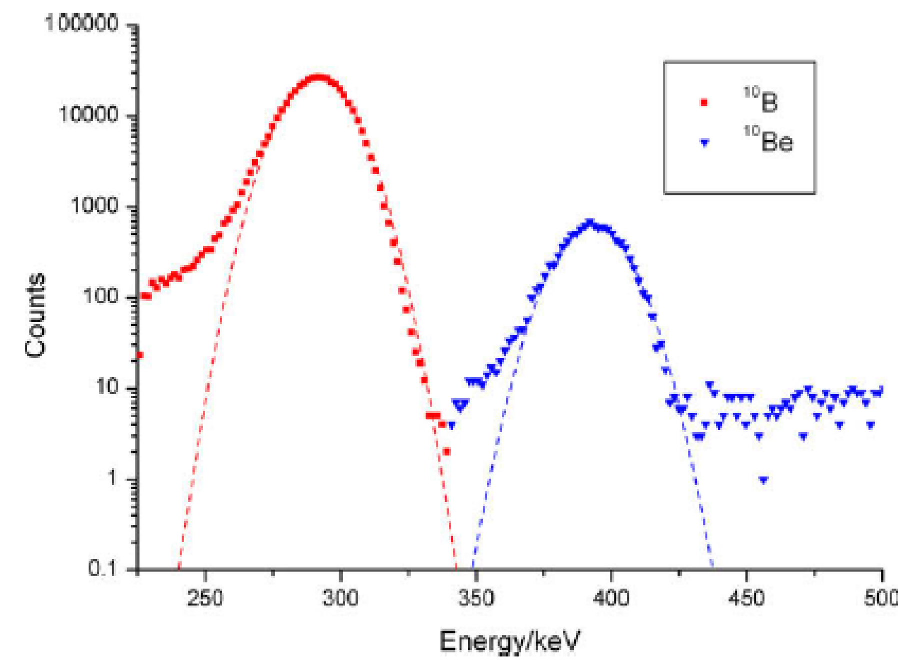
3. Proposed Comparative Study

→ New Detector vs. Old Detector

We intend to repeat the previous experiments at CNA with the aid of a new detector designed and built by ETH. We also hope to use the settings and system at ETH as a model for improved measurements of ^{10}**Be**.

New Detector Design built by ETH to aid in ^{10}**Be detection.**





Results from ETH 0.6 MV AMS system using the New Detector Design ^{10}**Be detection.**

Spectrum of a BeO Sample after passage through 490 nm $Si_3N_{3.1}$ *absorber in front of the gas ionization detector.*

Summary

To summarize, we intend to use the most recent experiment at ETH as a model to continue the measurements on the optimization of ^{10}**Be** detection. We hope to improve the previous measurements at CNA with the addition of a new detector built by ETH, sample preparation and possibly an additional magnet. Furthermore, we expect more sensitive results with the setup at the CNA laboratory because it is equipped with a 1MV AMS system compared to that of the 0.6 MV system at ETH.

Future Direction

Use the existing AMS system to detect other long lived radioisotopes (Al, C, I, Pu).

Acknowledgements

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