ETH Swiss Federal Institute of Technology Zürich

PSI PAUL SCHERRER INSTITUT
Ion Beam Physics

Investigation of natural $^{10}Be/^{9}Be$-ratios with Atomic Mass Spectrometry (AMS)

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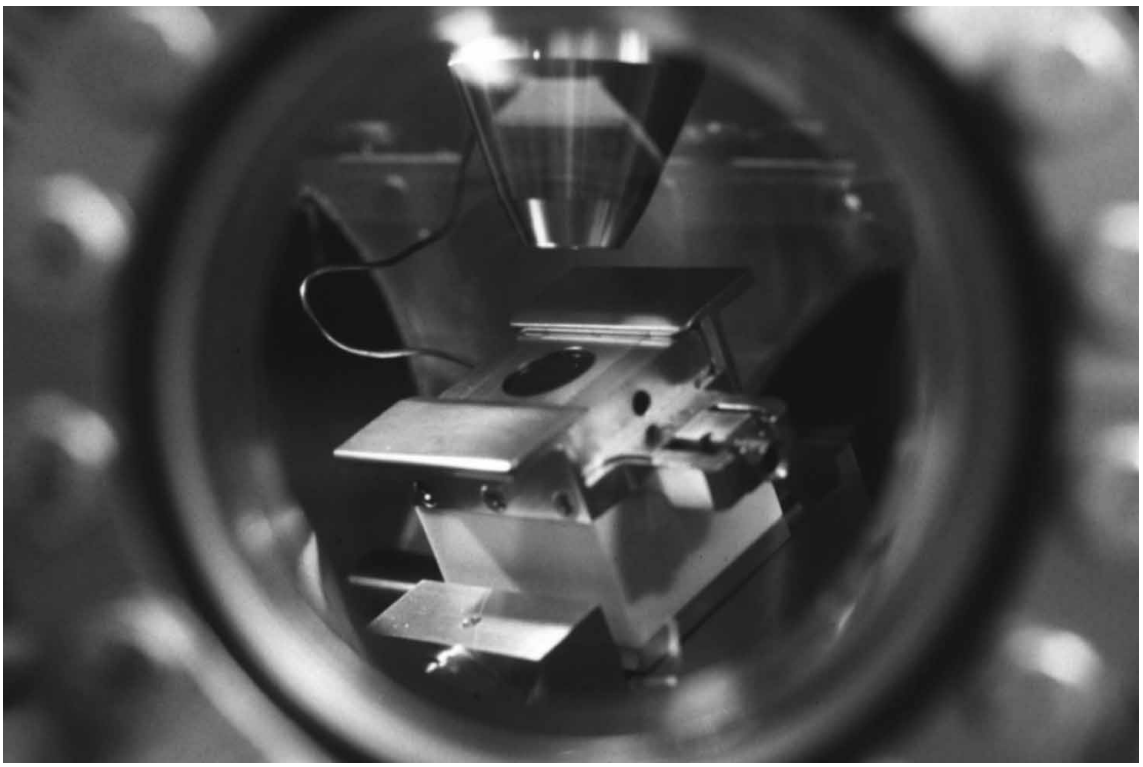

State of affairs

AMS is a commonly used method for measuring the absolute concentrations of ^{10}Be in environmental samples (rocks, deep-sea manganese crusts, etc.):

Be is isolated from the original sample matrix with a chemical procedure. Typical amounts of Be from a sample are a few hundred nanogram.

Several hundred microgram of ^{9}Be-carrier are added to the sample, so that the sample can be analyzed with the intense primary beams of conventional AMS-sources.

If the natural ^{10}Be/^{9}Be-ratio of a sample is of interest, then an independent measurement of the original sample has to be made; either of the absolute ^{9}Be-concentration with ICP-MS or of the ^{10}Be/^{9}Be-ratio with SIMS.

Motivation

- Sofar: With conventional ^{10}Be-AMS only the absolute ^{10}Be-concentration of the original sample can be measured.

  Goal: Development of a more sensitive method to measure the natural ^{10}Be/^{9}Be-ratio of a sample than with SIMS or the combination ICP-MS and AMS.

- Feasability study for measuring samples of sizes in the the 100 ng-range with AMS

- First step in the direction of „^{10}Be-AMS-measurements at low energies (~2.5 MeV)“

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Characteristics of a new method for measuring $^{10}Be/^{9}Be$-ratios with AMS

Focused Cs^{+}-primary beam
beam diameter: 100 µm
Cs^{+}-current: 600 nA

Sample preparation **without** adding ^{9}Be-carrier

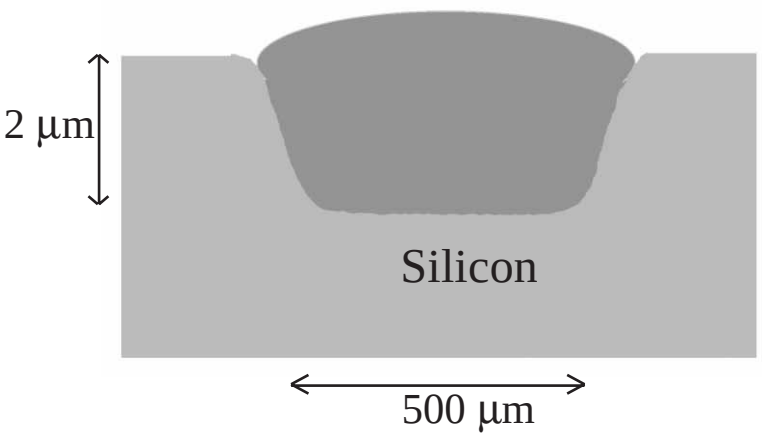
Sample sizes in the100 ng-range

Ion currents are 1000 smaller than in conventional ^{10}Be-AMS-measurements

$^{10}Be/^{9}Be$-ratios to be analyzed are 1000 times higher

Sample preparation

0.1 - 1 µl of a 1000 ppm $BeNO_3$- or $BeSO_4$-solution
is pipetted into a sputter crater on a Si-wafer

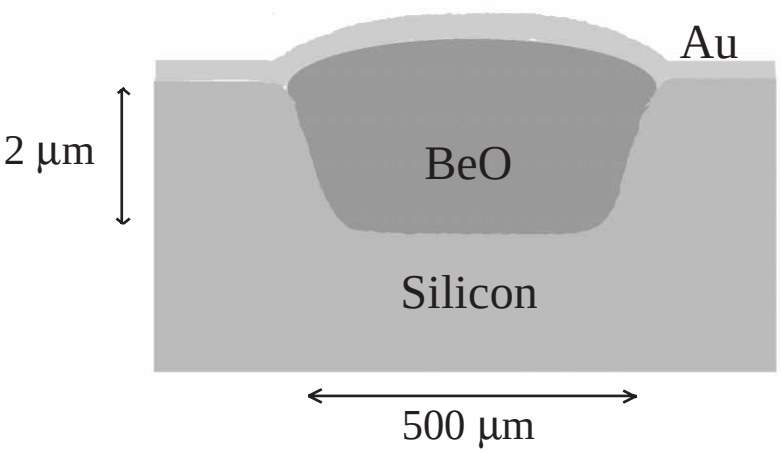


evaporate the disolvent at 65 - 75 °C

dry the samples by heating them in steps up to 180 °C

bake at 700 °C for about 120 minutes
($BeNO_3$ ---> $BeO + NO_2$)
($BeSO_4$ ---> $BeO + SO_3$)

coat Si-wafer with about 20 nm of Gold



Conclusion

AMS-measurement of natural $^{10}Be/^{9}Be$-ratios already shows the full potential of being able to compete with the complementary methods SIMS and ICP-MS in both sensitivity (10^{-9}) and precision (5-10%)

Instabilities of the measurement due to electrical charging of the sample still have to be solved.

Outlook

Test the method on samples from deep-sea Iron-Manganese-crusts and compare them to the results of other methods (ICP-MS and SIMS)

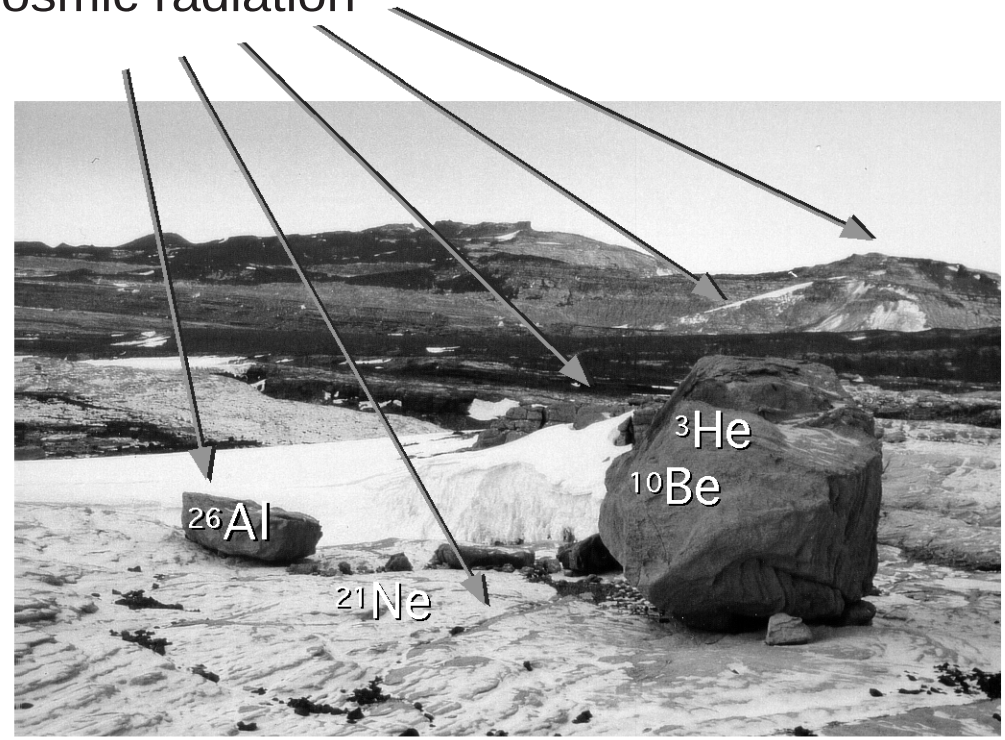
Chemical supression of Boron during sample preparation. 25 kHz ^{10}B in the detector have to be supressed by a factor of 100

Separation of ^{10}Be and ^{10}B directly in the $\Delta E/E$-gas ionisation detector (no need for a Boron-absorber in front of the detector)

Measurement of the $^{10}Be/^{9}Be$-ratio instead of the $^{10}Be/^{16}O$-ratio

Production of Radioisotopes

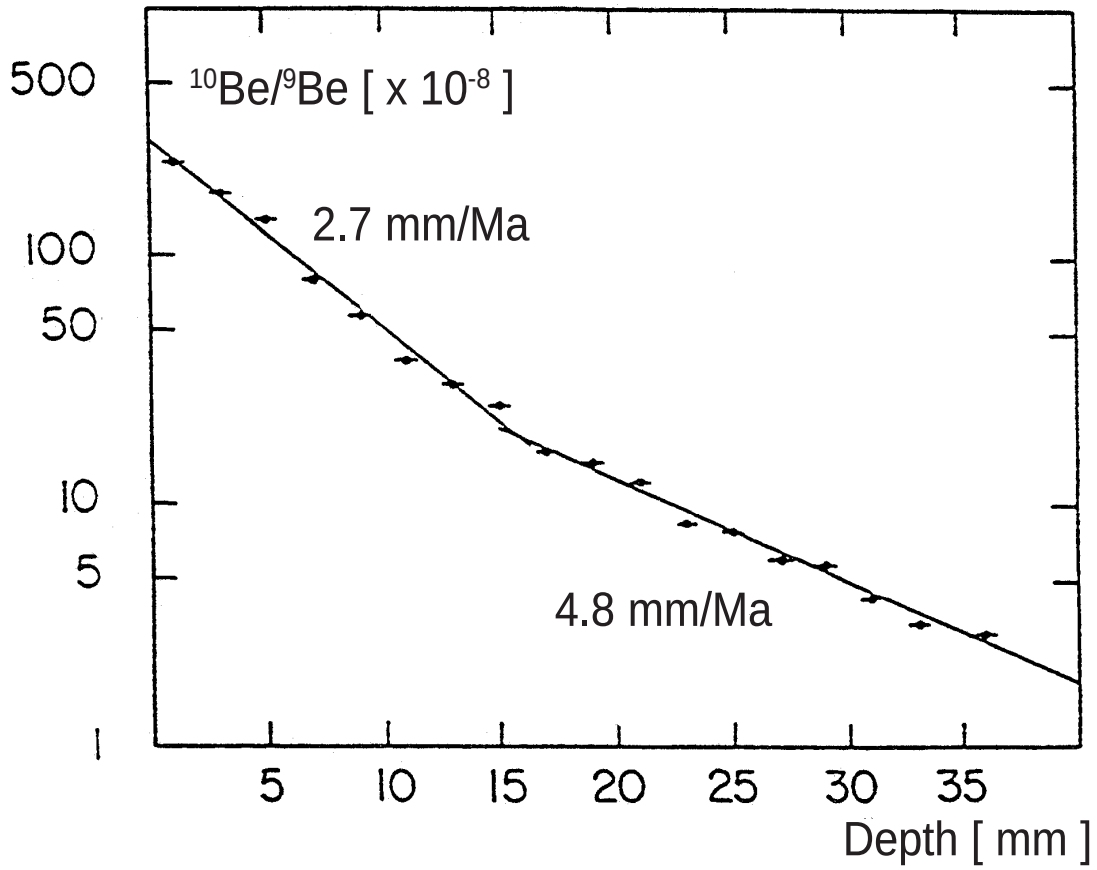
Cosmic radiation

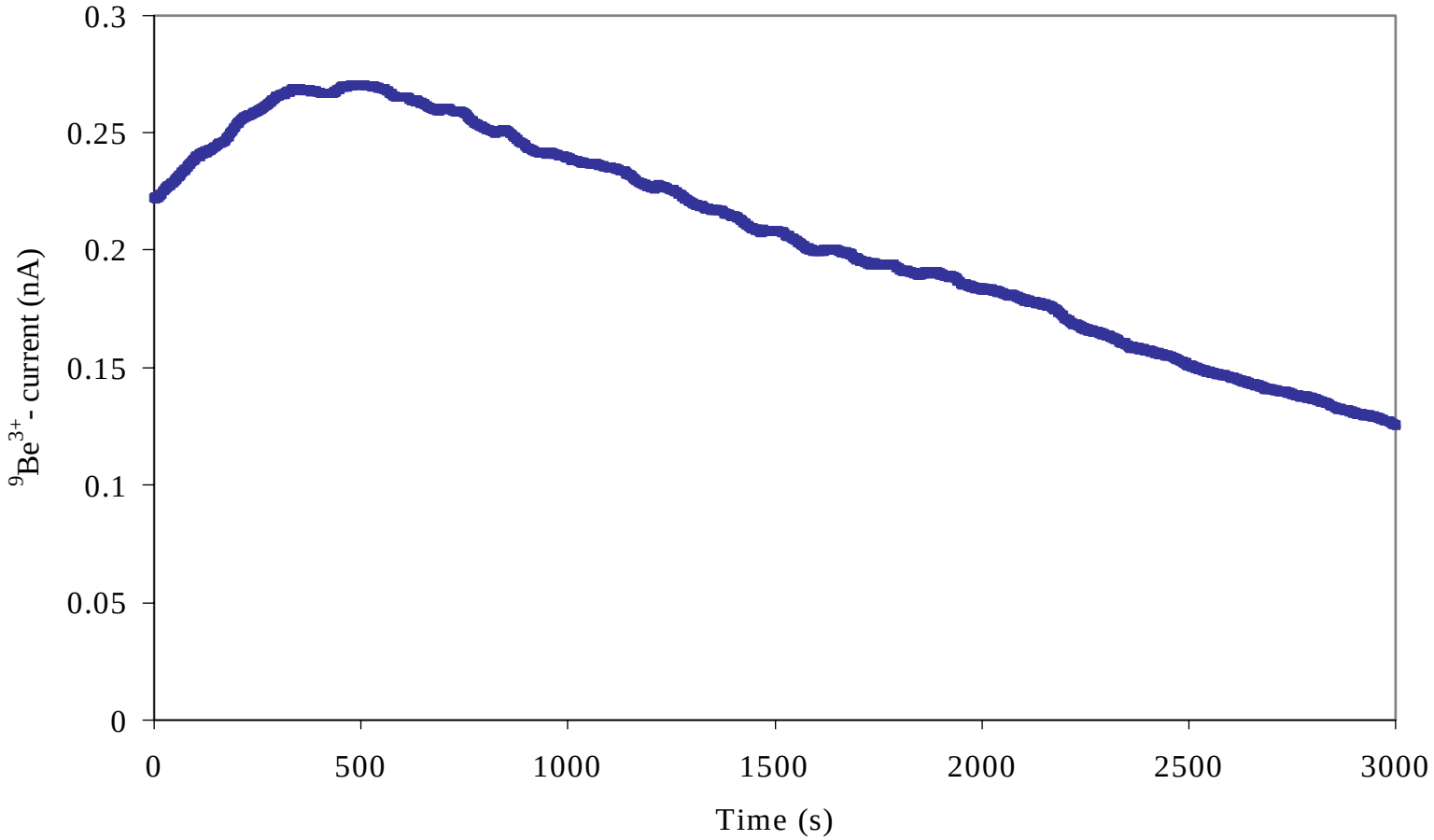


$^{16}O(n,4p3n)^{10}Be$, $^{28}Si(n,p2n)^{26}Al$

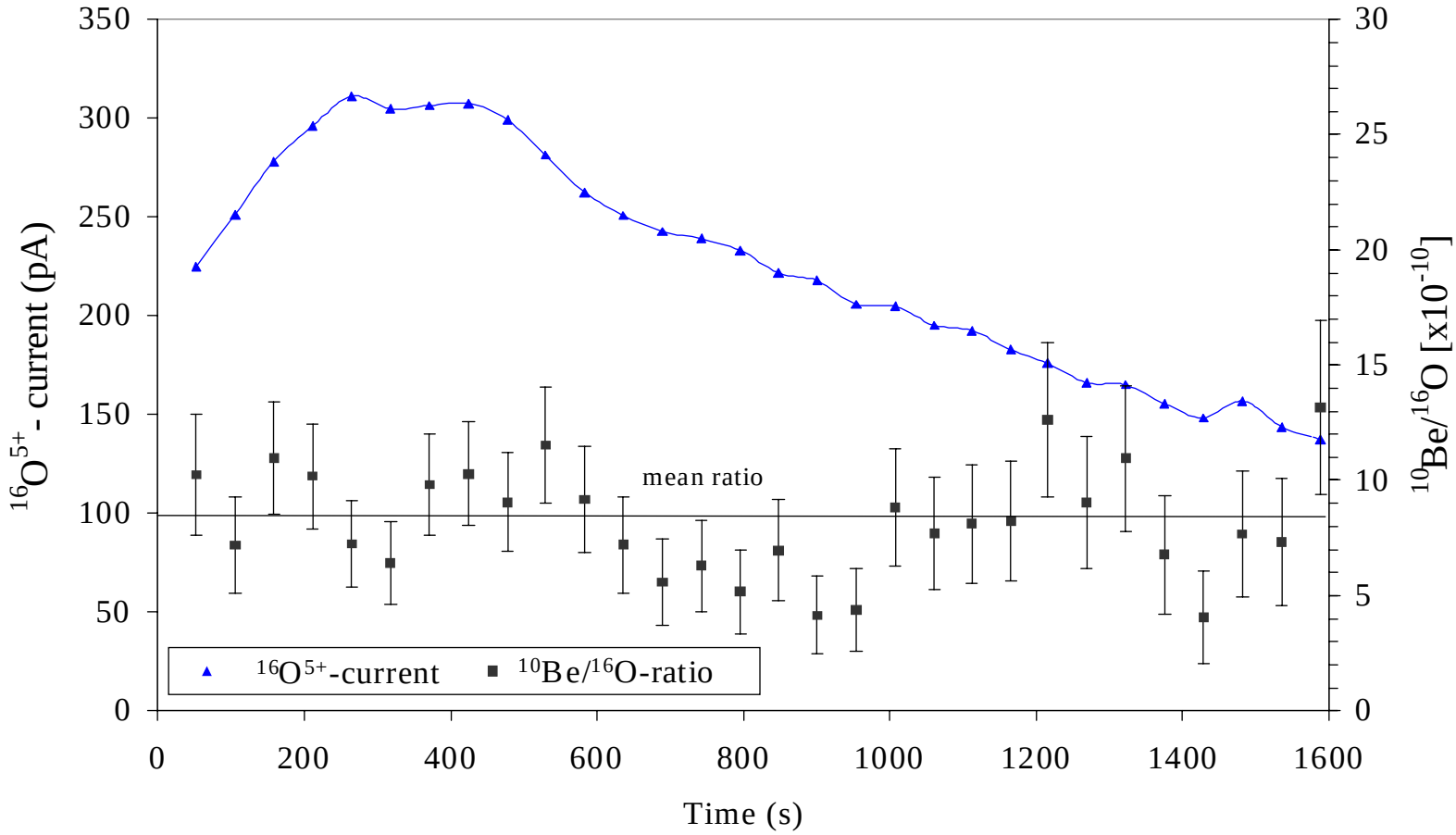
Cut through a Manganese-Crust

Growth Rate of a Manganese-Crust





Mean $^{9}Be^{3+}$-current against time
Scanning width of the Cs^{+}- primary beam: 300µm
Analyzed amount of BeO: < 100 ng

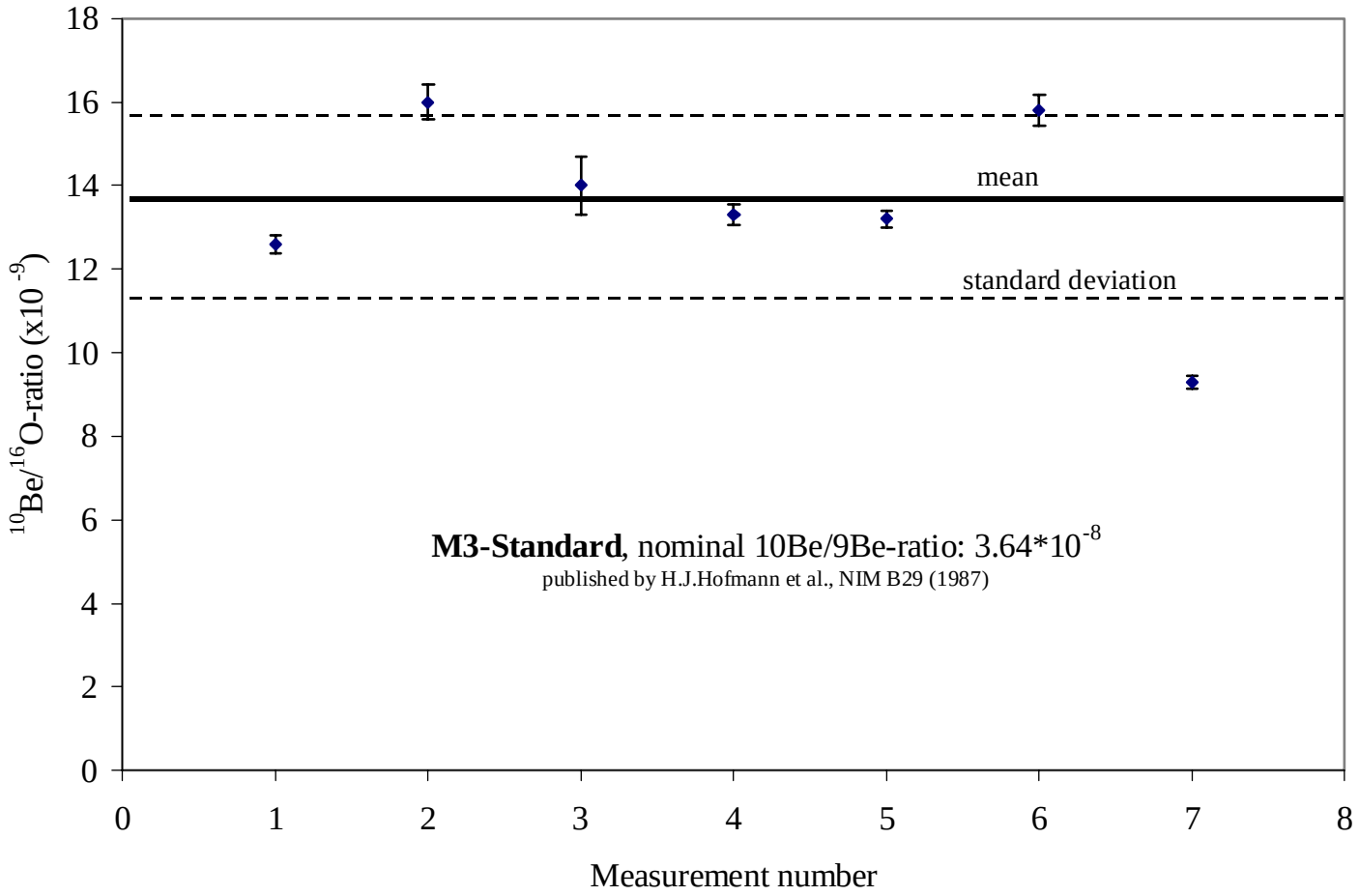


M4-Standard published by H.J. Hofmann et al., NIM B29 (1987)

measured ratio ($^{10}Be/^{16}O$): $0.82*10^{-9}$ error: 5.3%

nominal ratio ($^{10}Be/^{9}Be$): $1.08*10^{-9}$

Reproducibility



Comparison of measured standards