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An Enrichment System for Precise Dating with ^{39}Ar

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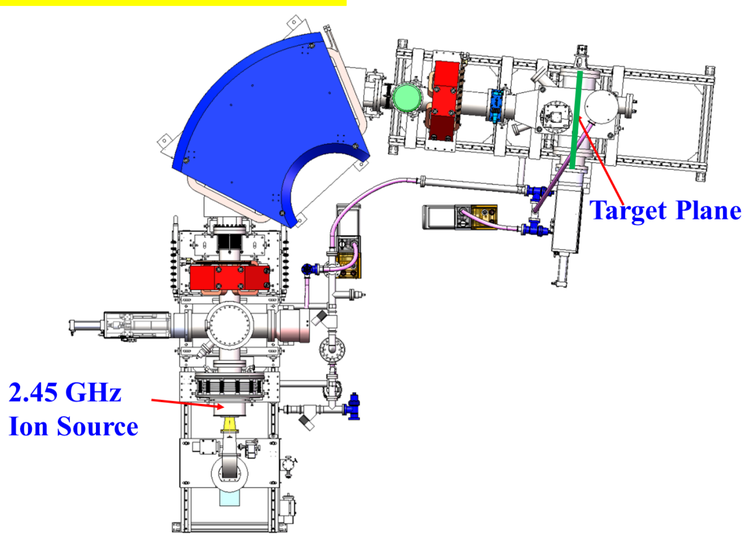
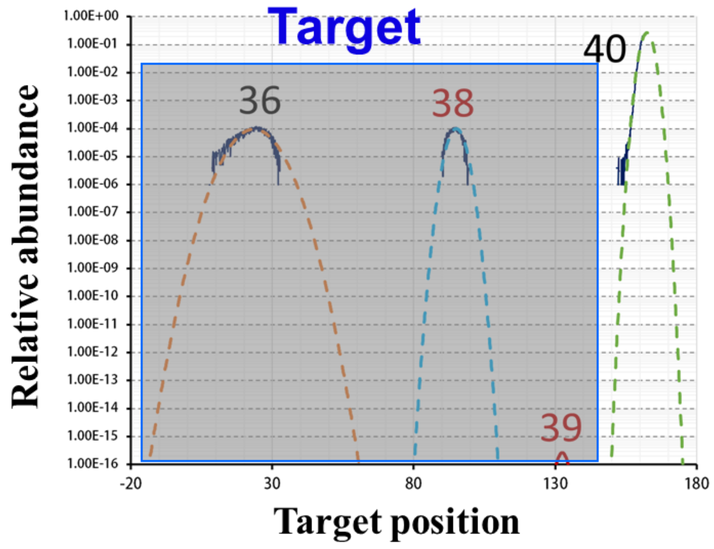
Abstract

To improve the dating efficiency of ^{39}Ar Atom Trap Trace Analysis (^{39}Ar-ATTA), an enrichment system has been developed at IMP. Sample Ar atoms will be ionized, transported and separated in system. Finally, ions are selectively collected by aluminum target. Series of experiments have been finished to test system performance, and the enriched aluminum foils were measured with ^{39}Ar-ATTA at USTC. These experiments demonstrate that the enrichment system can enhance the ^{39}Ar's abundance more than 100 times. In addition, the enrichment process can preserve sample information well. This system equips the conditions for practical dating pre-enrichment. Recently, several ice and water dating samples have been enriched successfully.

Experimental Setup



Schematic map of enrichment platform



The diagram of collection target setup

System parameters

Ion species	Ar^+
Beam energy (keV)	~ 30
Total beam current	~ 2 mA
Pressure (10^{-6} mbar)	1.3 - 3.0
Target material	Aluminum
Measure	^{39}Ar-ATTA, USTC

Experimental Results

Enrichment factor

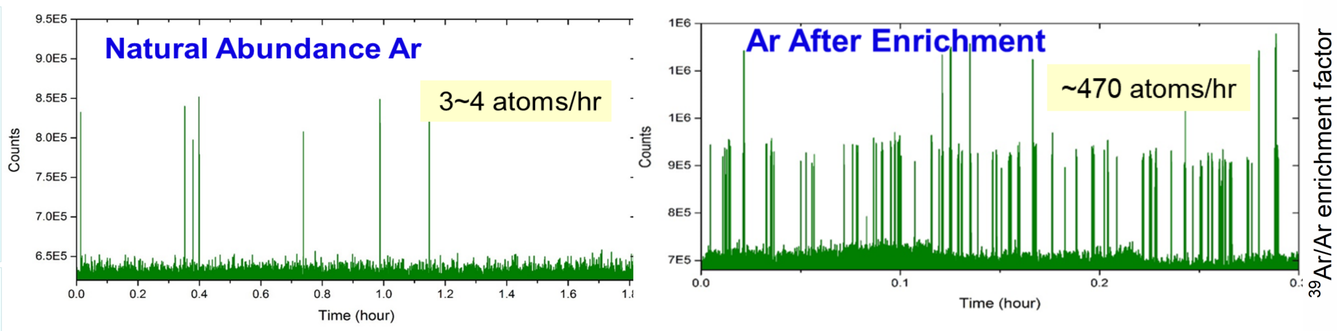
☐ Enrichment factor = $\frac{^{38Ar}/_{Ar_0}}{^{38Ar}/_{Ar_1}}$

Ar_0: Natural argon,

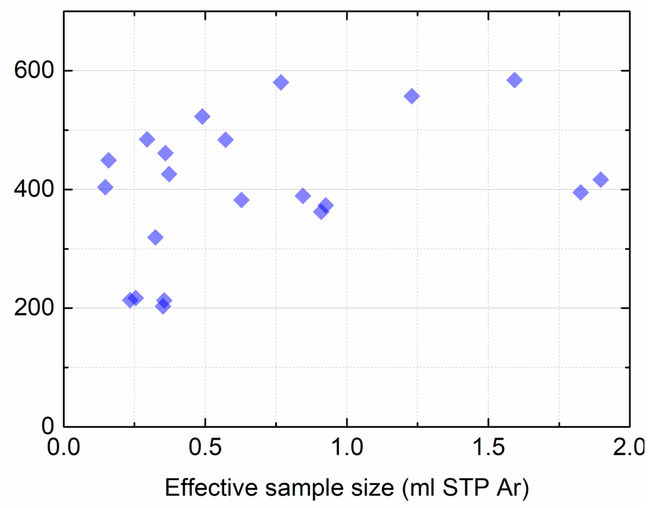
Ar_1: Ar after enrichment

☐ Effective sample size = $\frac{V_{38_{Ar}}}{0.063\%}$

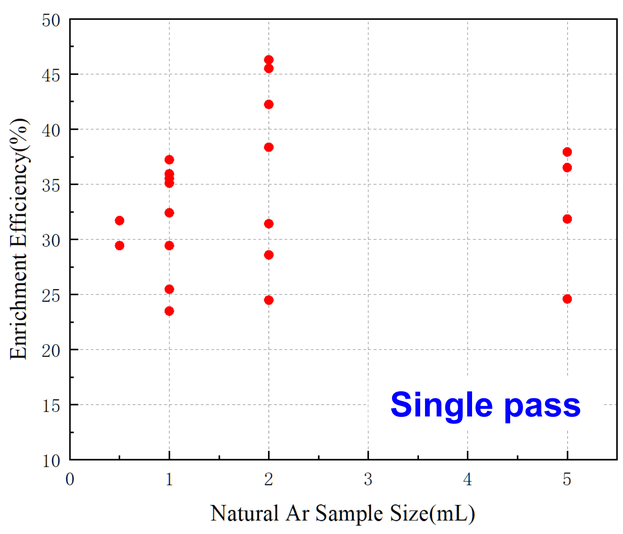
0.063%: ^{38}Ar natural abundance



^{39}Ar-ATTA count rate of natural and enriched sample



Enrichment efficiency



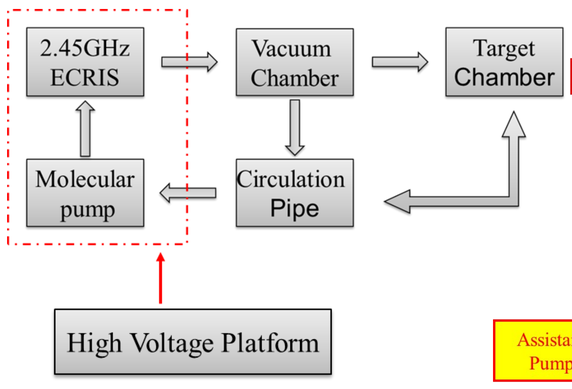
☐ $(1-\eta)^n \leq 1-\zeta$

η: enrichment efficiency with single pass

ζ: Target efficiency

n: Multi-pass times

0.063%: ^{38}Ar natural abundance



30% efficiency can not satisfy the ATTA dating requirements on very old samples. Circulation enrichment is demanded.

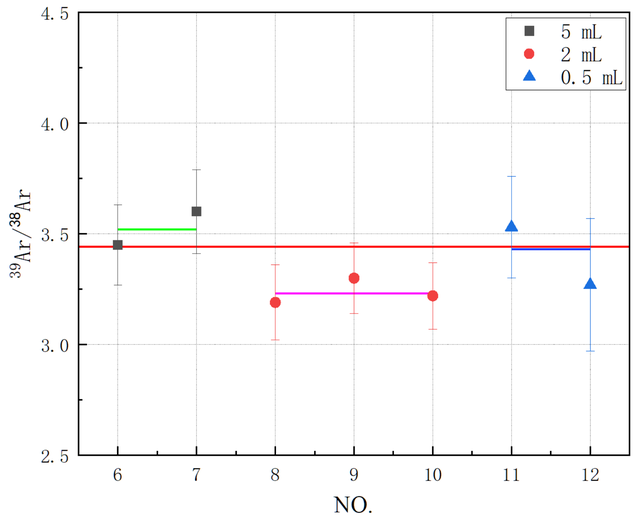
Schematic map and picture of circulation system

Enrichment reliability

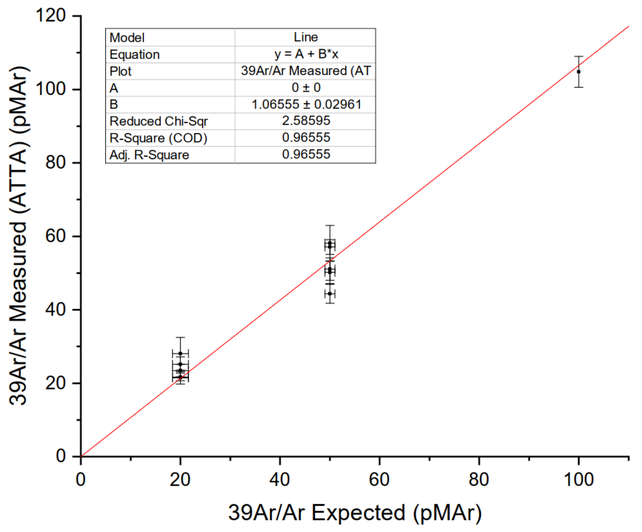
	S1	S2
^{39}Ar Abundance	Natural	20 pMAr 50 pMAr

☐ pMAr: percent to Modern Ar.

☐ 20 pMAr means: $\frac{Sample(^{39Ar}/_{Ar})}{Natural(^{39Ar}/_{Ar})} = 0.2$



S1：^{39}Ar/^{38}Ar relative value of enriched and natural



S2：^{39}Ar/Ar value of samples and enriched

☐ High consistency of measured and expected ^{39}Ar/Ar ratio.

☐ A very small constant offset is existed and could be corrected based on standard sample enrichment results.

Summary

☐These experimental results demonstrate that this enrichment system can increase ^{39}Ar abundance more than 100 times.

☐The average efficiency of single-pass is more than 30%.

☐Gas circulation mode was tested for about 5 hrs and showed high stability, in which enrichment efficiency is expected to reach 100%.

☐Experiments give a clear evidence that the system has a good enrichment reliability. System equips the conditions for practical dating pre-enrichment.