

CTBT:
SCIENCE AND
TECHNOLOGY
2017 CONFERENCE

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**First Calculations on the Production of Ar37 in Nuclear
Power Plants in Regard to the Verification of the Nuclear
Test Ban Treaty**

...The story thus far:



Argon



On-Site
Inspection

Xenon



International
Monitoring
System

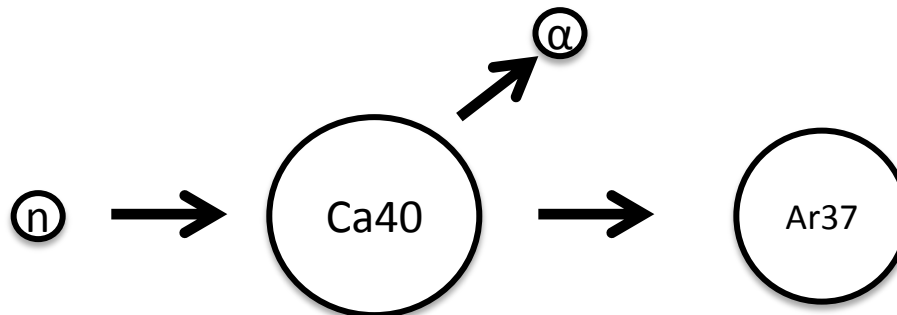
Xenon is the best we have...

...if we have Xenon

Nuclear test	Xe135	Xe133	Xe133m	Xe131m
09.10.06	-	RN16	-	-
25.05.09	-	-	-	-
12.02.13	-	JPX38, RUX58	-	JPX38, RUX58
06.01.16	-	-	-	-
09.09.16	-	-	-	-

Argon as a noble alternative

- | | | |
|----------------------------------|------------------|------------------|
| • Relevant isotopes: | Ar37 | Ar41 |
| • Half life: | 35days | 109 min |
| • Produced in nuclear explosions | Ca40 (n, α) Ar37 | |
| • Produced in nuclear reactors? | Ca40 (n, α) Ar37 | Ar36 (n, γ) Ar37 |



The fuel assembly

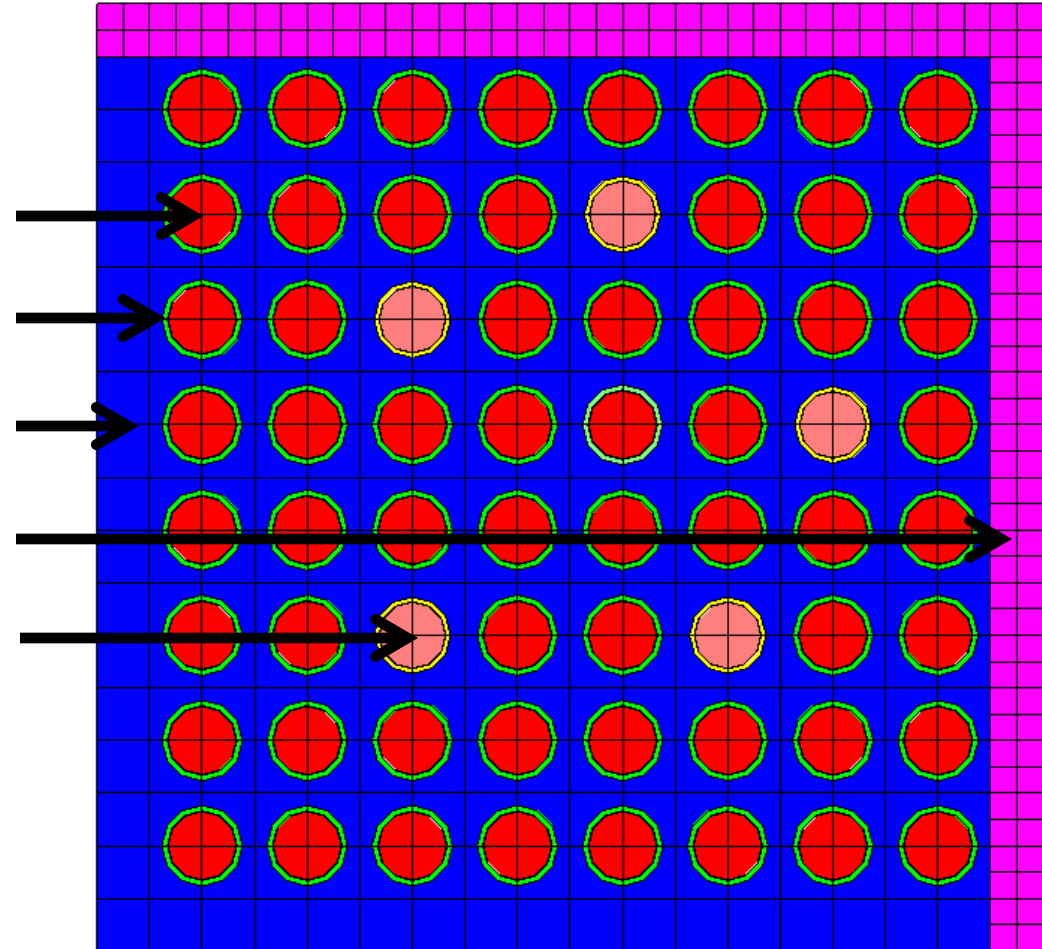
Fuel: UO_2 3,2% enrichment

Cladding tube: Zircaloy

Moderator: H_2O + Bor

Neighboring assembly

Absorber: Ag+In+Cd



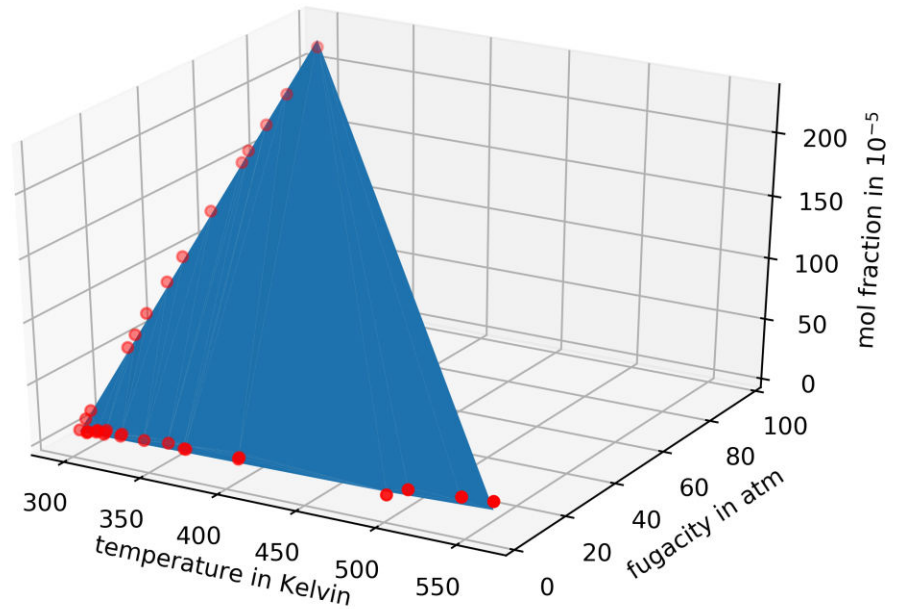
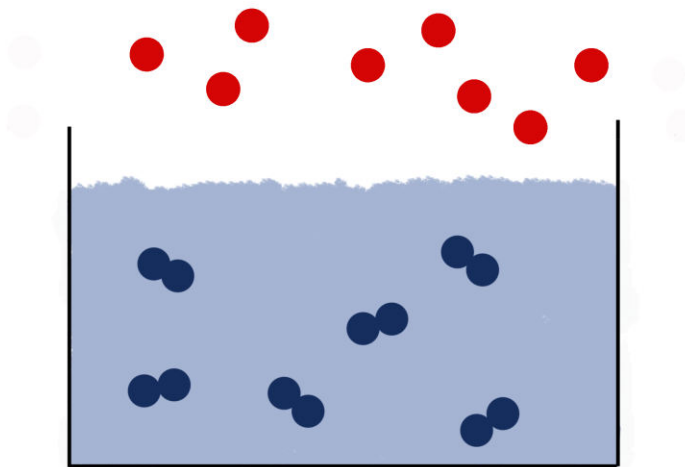
Nuclear Systems Modeling & Simulation



Ar36 in water

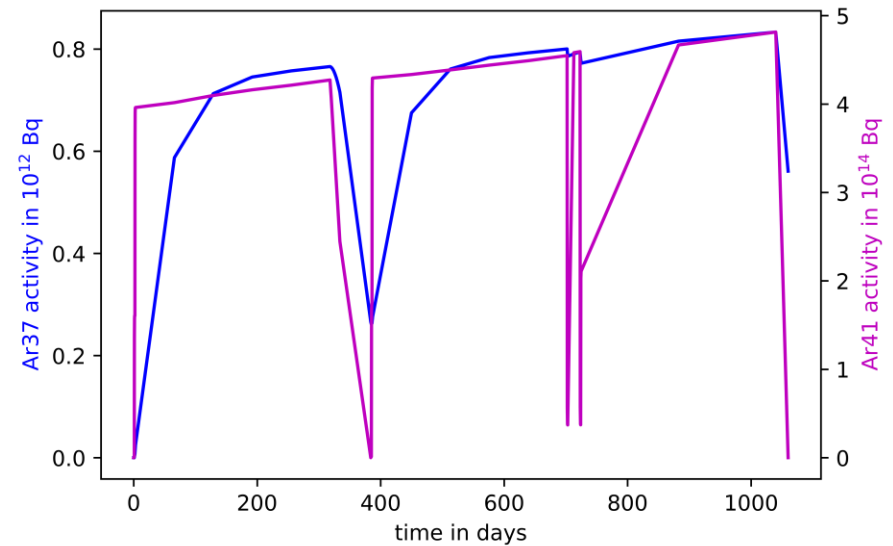
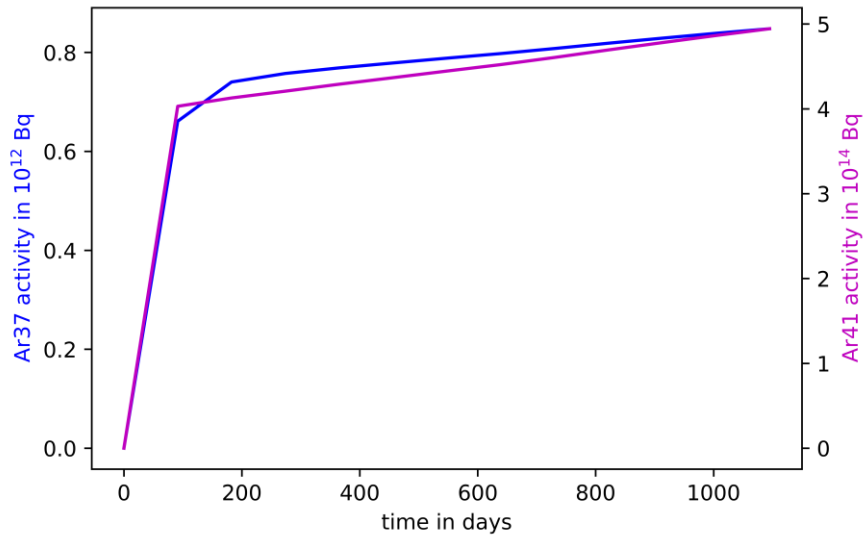
for 153 atm & 598 K

→ mol fraction: 0.036



Potter II & Clynne, 1978 and Kennan & Pollack, 1990

Relation between Ar37 and Ar41



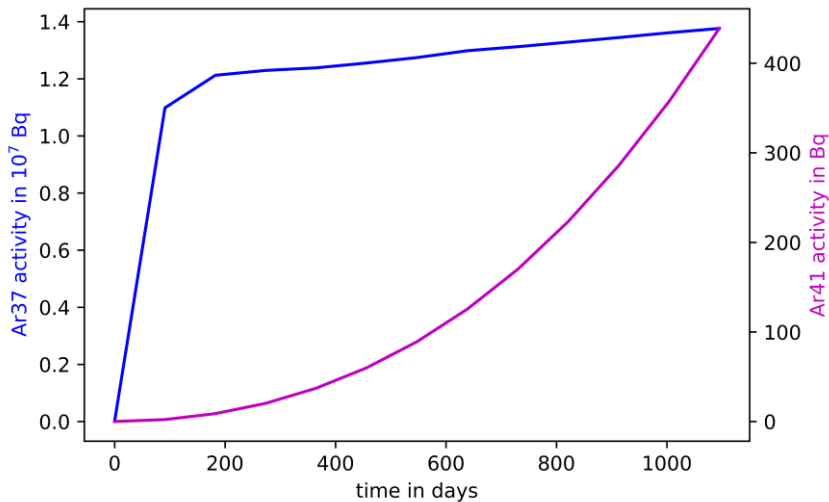
Amount of Argon produced: 10^{-4} grams



———— Ca40 in cladding ————

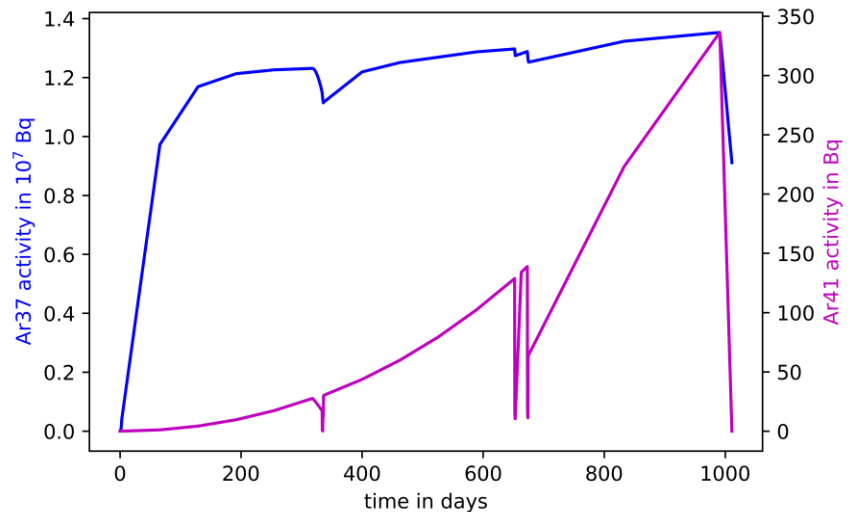
Ca impurity of the cladding tube

10^{-8} g UO_2 per cm^2 cladding



3 years equilibrium

For the same amount as via activation: $\sim 10^{-3}$



various possible operating modes



Next steps

- Contribution to global Argon-background → Geometry
- Activation in Air
- Research reactor

Résumé

- Activation in cooling water:
 - Clear link between Ar37 and Ar41
 - But: different sensitivity to power changes
- Ar37 is proportional to Ar36 dissolved in water
- Ca impurity: no relevant contribution



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Thank you.
Questions are welcome.



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Bonus



One does not simply change from Xenon to Aragorn

The Solubility of the Noble Gases He, Ne, Ar, Kr, and Xe in Water up to the Critical Point

Robert W. Potter II¹ and Michael A. Clynne¹

Received February 24, 1978; revised June 7, 1978

The solubility of the noble gases Ar, He, Ne, Kr, and Xe in pure water was measured from 298 to 561°K. These data in turn were extrapolated to the critical point of water, thus providing a complete set of Henry's law constants from 274 to 647°K when combined with the existing literature data. Equations describing the behavior of the Henry's law constants over this temperature range are also given. The data do not confirm extrapolations of empirical correlations based on low-temperature solubility data.

KEY WORDS: Solubility of Ar, He, Ne, Kr, and Xe in water; critical point.



Pressure dependence of the solubility of nitrogen, argon, krypton, and xenon in water

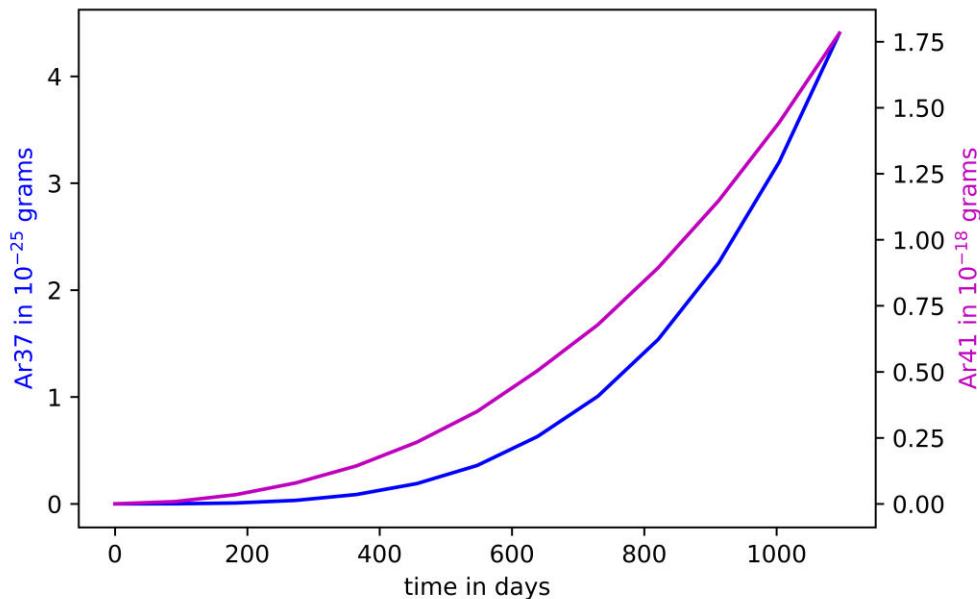
Richard P. Kennan and Gerald L. Pollack

Citation: **93**, 2724 (1990); doi: 10.1063/1.458911

View online: <http://dx.doi.org/10.1063/1.458911>

View Table of Contents: <http://aip.scitation.org/toc/jcp/93/4>

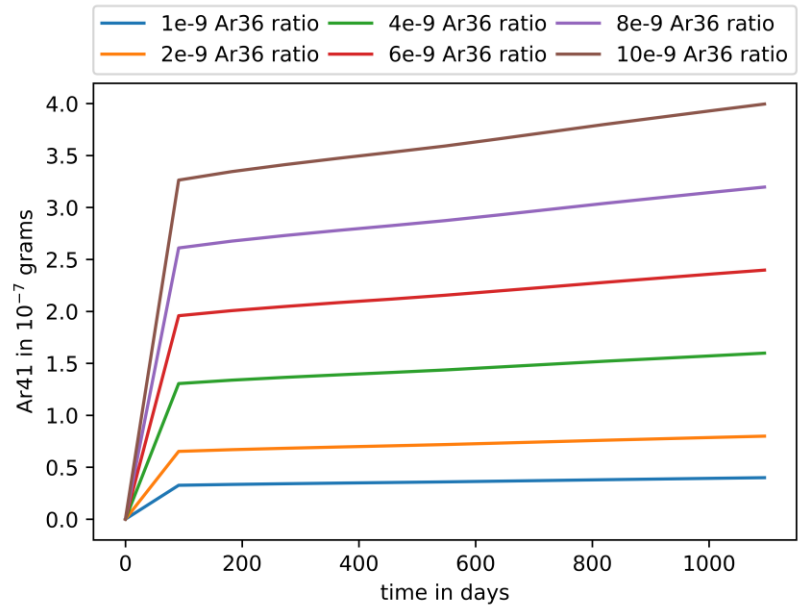
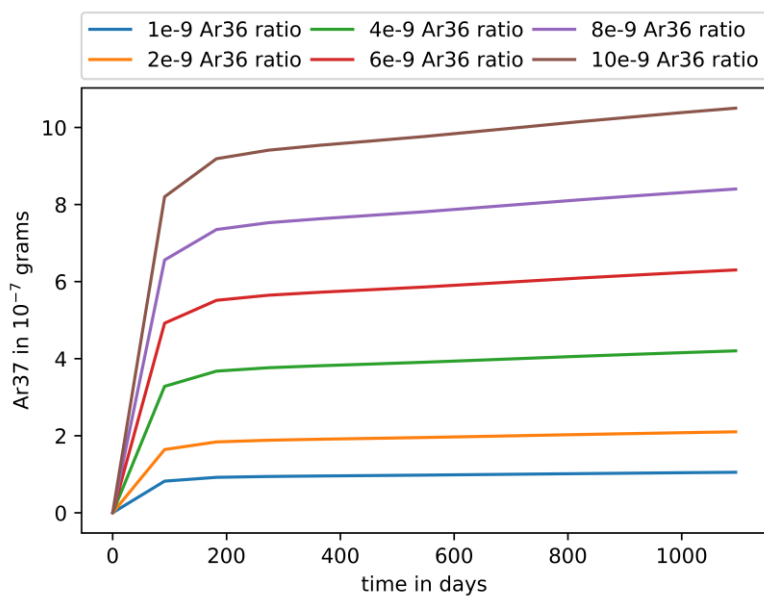
Published by the [American Institute of Physics](#)



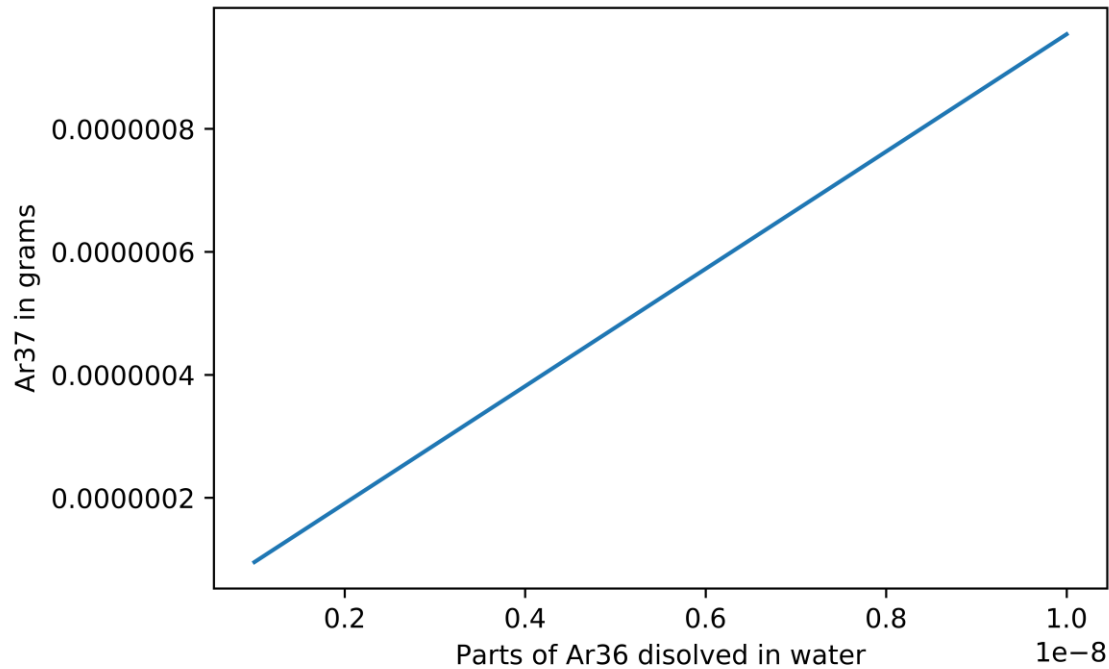
Possible scenarios:

- Ar36 in water
- Ca40 in cladding
- Effect of coolant decontamination

How much Ar36?

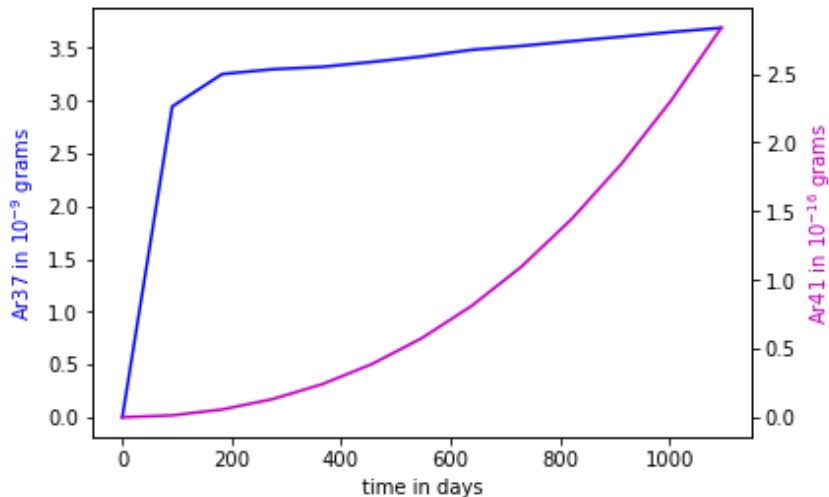


Relation between Ar37 and Ar41 in equilibrium



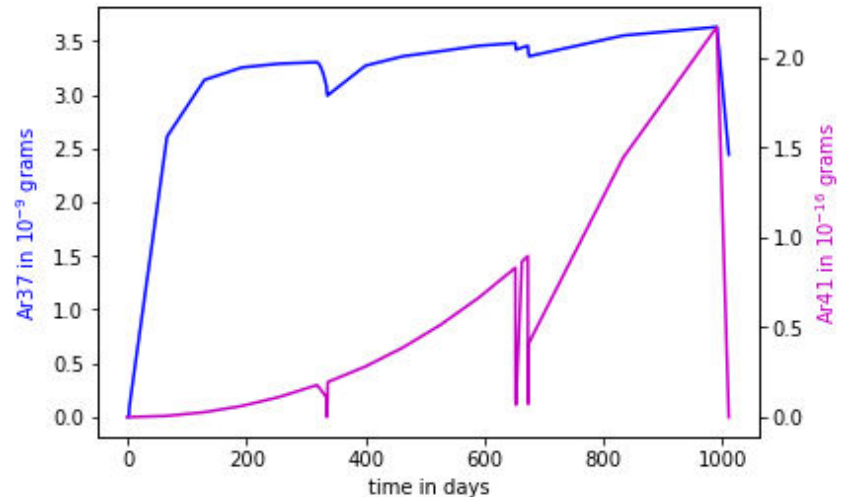
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various possible operating modes