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Progress on using deuteron-deuteron fusion generated neutrons for ^{40}Ar/^{39}Ar sample irradiation

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We present progress on the development and proof of concept of a deuteron-deuteron fusion based neutron generator for ^{40}Ar/^{39}Ar sample irradiation. Irradiation with deuteron-deuteron fusion neutrons is anticipated to reduce Ar recoil and Ar production from interfering reactions. This will allow dating of smaller grains and increase accuracy and precision of the method.

The instrument currently achieves neutron fluxes of $\sim 9\times 10^7$ cm^{-2}s^{-1} as determined by irradiation of indium foils and use of the activation reaction ^{115}In(n,n')^{115m}In. Multiple foils and simulations were used to determine flux gradients in the sample chamber. A first experiment quantifying the loss of ^{39}Ar is underway and will likely be available at the time of the presentation of this abstract.

In ancillary experiments via irradiation of K salts and subsequent mass spectrometric analysis we determined the cross-sections of the ^{39}K(n,p)^{39}Ar reaction at $\sim$2.8 MeV to be 160 $\pm$ 35 mb (1σ). This result is in good agreement with bracketing cross-section data of $\sim$96 mb at $\sim$2.45 MeV and $\sim$270 mb at $\sim$4 MeV [Johnson et al., 1967; Dixon and Aitken, 1961 and Bass et al. 1964]. Our data disfavor a much lower value of $\sim$45 mb at 2.59 MeV [Lindström & Neuer, 1958]. In another ancillary experiment the cross section for ^{39}K(n,α)^{36}Cl at $\sim$2.8 MeV was determined as 11.7 $\pm$ 0.5 mb (1σ), which is significant for ^{40}Ar/^{39}Ar geochronology due to subsequent decay to ^{36}Ar as well as for the determination of production rates of cosmogenic ^{36}Cl. Additional experiments resolving the cross section functions on ^{39}K between 1.5 and 3.6 MeV are on their way using the LICORNE neutron source of the IPN Orsay tandem accelerator. Results will likely be available at the time of the presentation of this abstract.

While the neutron generator is designed for fluxes of $\sim 10^9$ cm^{-2}s^{-1}, arcing in the sample chamber currently limits the power—straightforwardly correlated to the neutron flux—the generator can safely be run at. Further technical improvements are necessary to increase the neutron flux to make geologic sample irradiation possible in a reasonable experimental timeframe.

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