# Validation of a method for indirectly constraining neutron-capture cross sections


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One of the prevalent questions in nuclear science is the origin of the elements. There are two stellar nucleosynthesis processes considered to be responsible for the production of the majority of the abundances of the elements heavier than iron; the slow neutron capture process (s-process) and the rapid neutron capture process (r-process). Both of these processes are characterized by the successive capture of neutrons on nuclei, with the major differences being the timescale over which the processes occur and the host environment. The s-process proceeds slowly along the valley of stability and the neutron captures involved are amenable to direct measurements. The r-process progresses through an explosive event with high neutron densities which drives material far from stability. The observation of a neutron star merger event by LIGO and Virgo and the subsequent electromagnetic followup has demonstrated that an r-process event can occur in these rare events, but it has not ruled out other potential astrophysical sites. In order to better understand and model the r-process, many nuclear properties are needed for a large number of nuclei, including neutron-capture cross sections. R-process nuclei are not viable for direct measurement of neutron-capture cross sections due to short half-lives, so the neutron-capture cross sections are theoretically predicted. Several indirect measurement techniques have been developed to provide experimental constraints on neutron-capture cross sections. One such method is the $\beta$-Oslo method, which uses $\beta$-decay to populate highly excited states of a nucleus. The resulting de-excitation via the emission of $\gamma$-rays is used to extract statistical nuclear properties of the daughter nucleus. These properties are then used as input in a reaction model to constrain the neutron-capture cross section. The $\beta$-Oslo method can provide a large number of constrained neutron-capture cross sections far from stability but it is necessary to validate the method using a direct neutron capture measurement. This method will be validated in the A = 80 mass region with the $^{82}$Se(n,$\gamma$)$^{83}$Se reaction. $^{83}$Se, can be accessed through the $\beta$-decay of $^{83}$As, which has been studied at the National Superconducting Cyclotron Laboratory with the total absorption spectrometer, SuN. Using the $\beta$-Oslo method, the cross section of $^{82}$Se(n,$\gamma$)$^{83}$Se was constrained and will be presented. The direct measurement of the $^{82}$Se(n,$\gamma$)$^{83}$Se reaction has been measured at the Los Alamos Neutron Science Center with the Detector for Advanced Neutron Capture Experiments and preliminary results will be presented.