Stacked Target Cross Section Measurements at Crocker Nuclear Laboratory

Nuclear Science & Security Consortium

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Cross Section Measurements

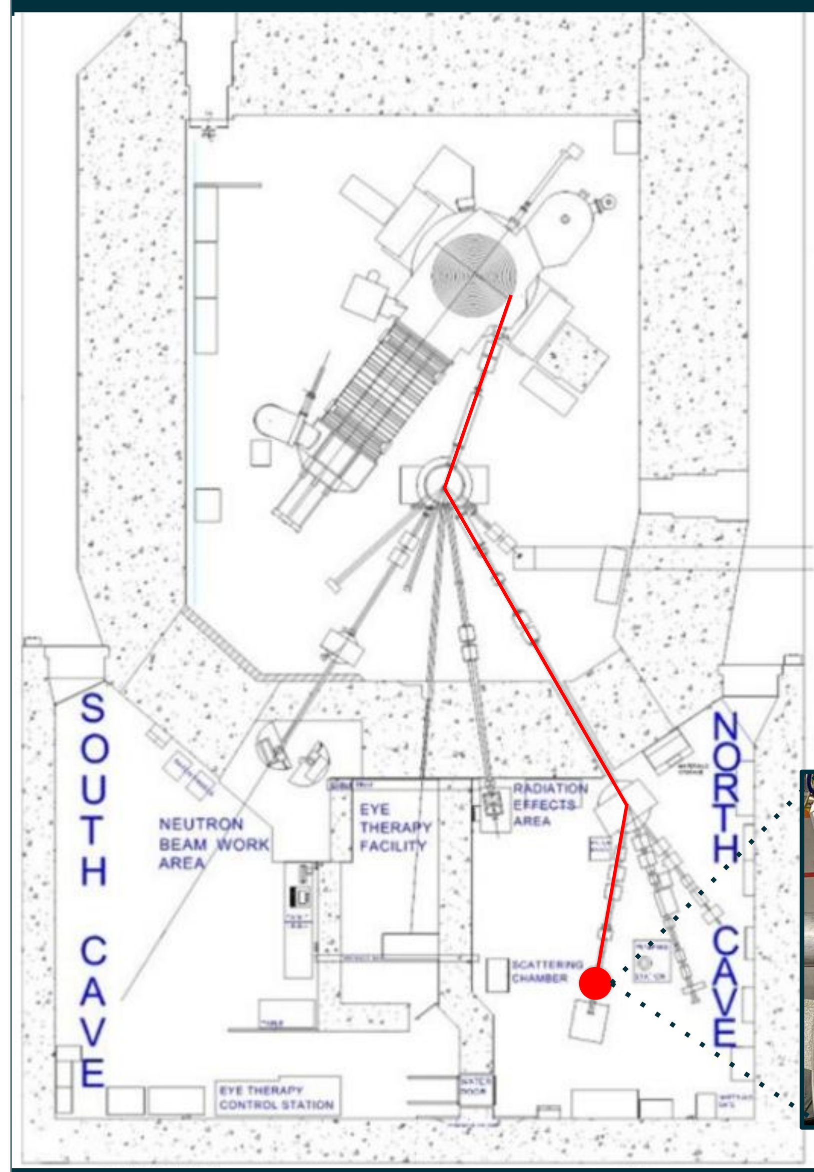
Motivation

Improved nuclear data is vital for a variety of fields, ranging from nuclear energy to astrophysics. While a large database of these reactions is available through the National Nuclear Data Center, in lower energy ranges there remain gaps in the table.

^{59}Co(p,3n)Ni^{57} and ^{93}Nb(p,n)Mo^{93} Cross Sections

The evaluation of these cross sections serves as a preliminary test with well-established cross section data to prepare for future cross section measurements at Crocker Nuclear Laboratory that have less data available.

Crocker Nuclear Laboratory

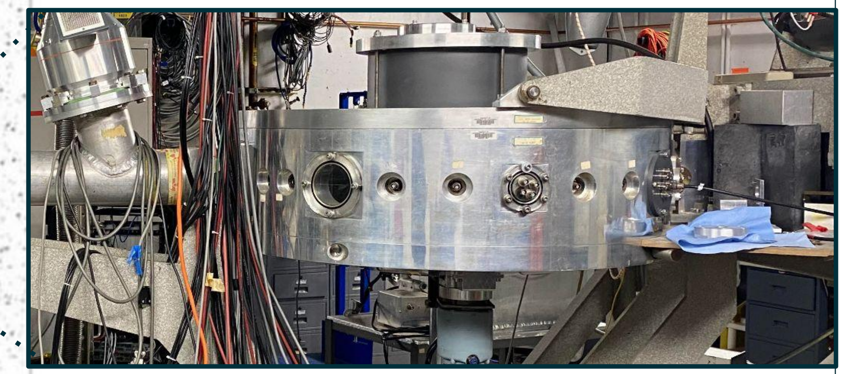


76" Isochronous Cyclotron at UCD

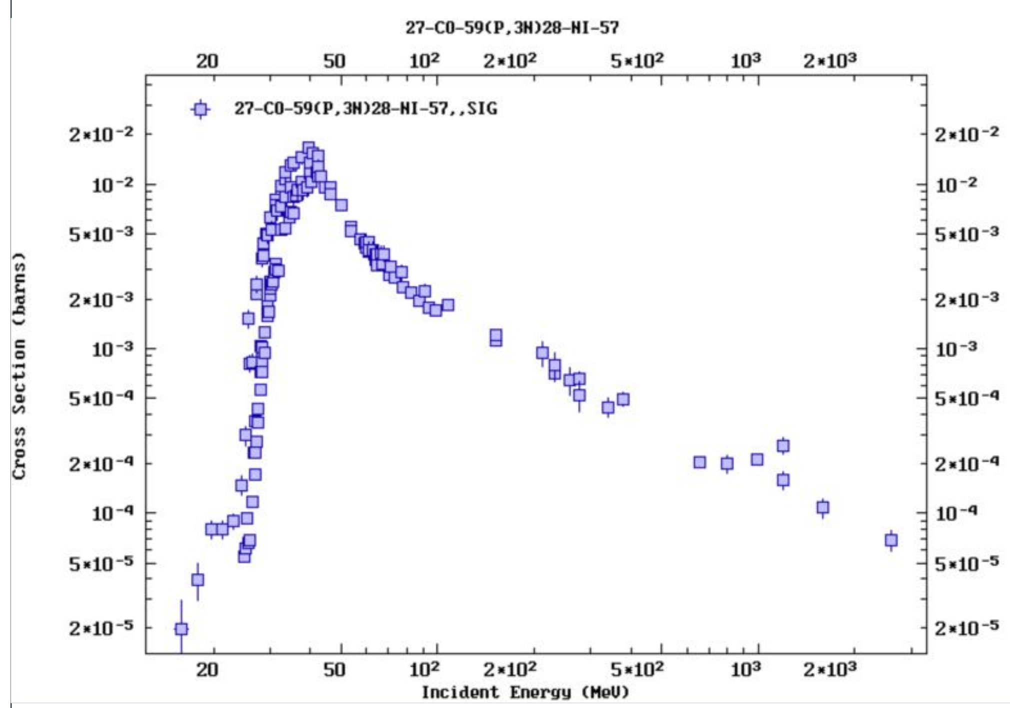
- produces beam between 4 MeV and 67.5 MeV
- accelerates protons, deuterons, helions, alphas, and neutrons
- lower energy capability makes it ideal for cross section measurements in that range

Target Stack Placement

The target will be placed in the scattering chamber at the end of the 1C beamline, shown below.



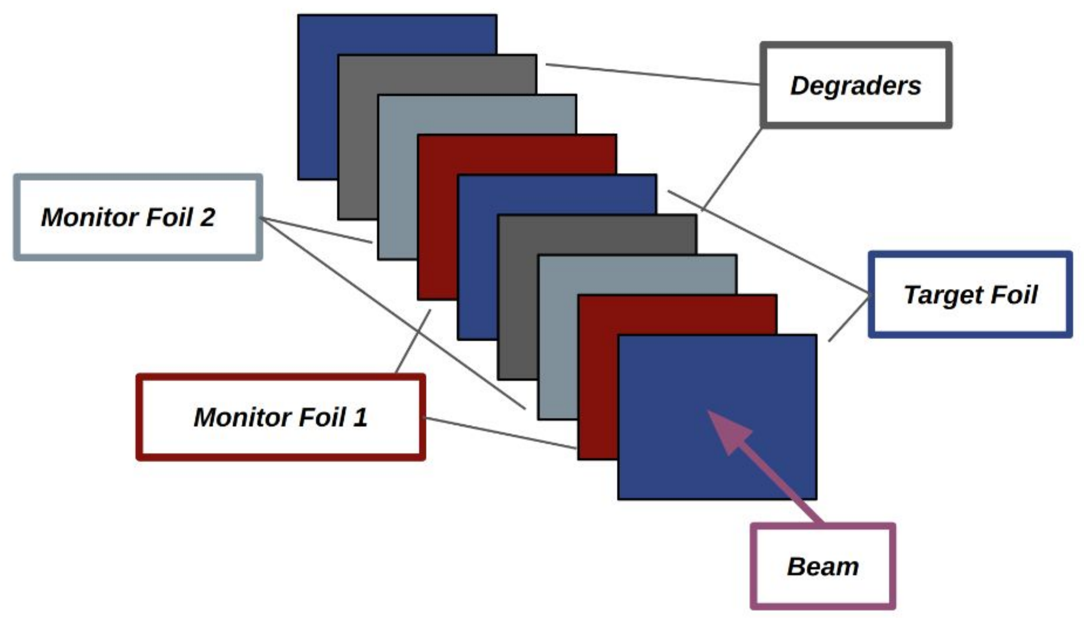
Reaction Selection



The ^{59}Co(p,3n)Ni^{57} and ^{93}Nb(p,n)Mo^{93} reactions have well-established data available, making them ideal test cases for the method that will allow future cross section measurements at Crocker.

To illustrate, a plot from EXFOR database shows the cross section data for the cobalt reaction.

Stacked Target Method



Overview

The stacked-target cross section measurement technique involves the use of monitor foils interspersed with energy degraders to measure the cross section of a particular **target foil (Co, Nb)**.

Monitor foils (Al, Cu) with known cross sections characterize the incident beam as it propagates through the target stack.

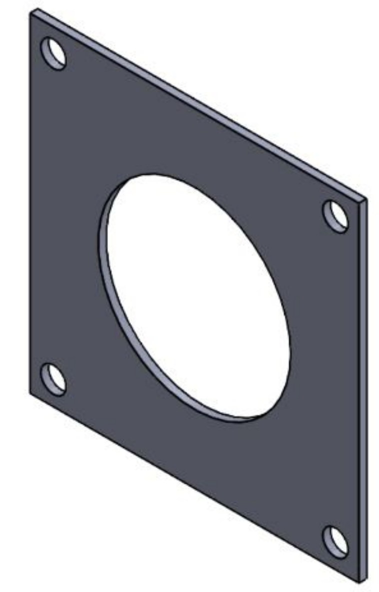
Degraders (Al) reduce the beam energy as it travels to allow for the measurement of cross section values over a certain energy spectrum.

Target Stack Construction and Modeling

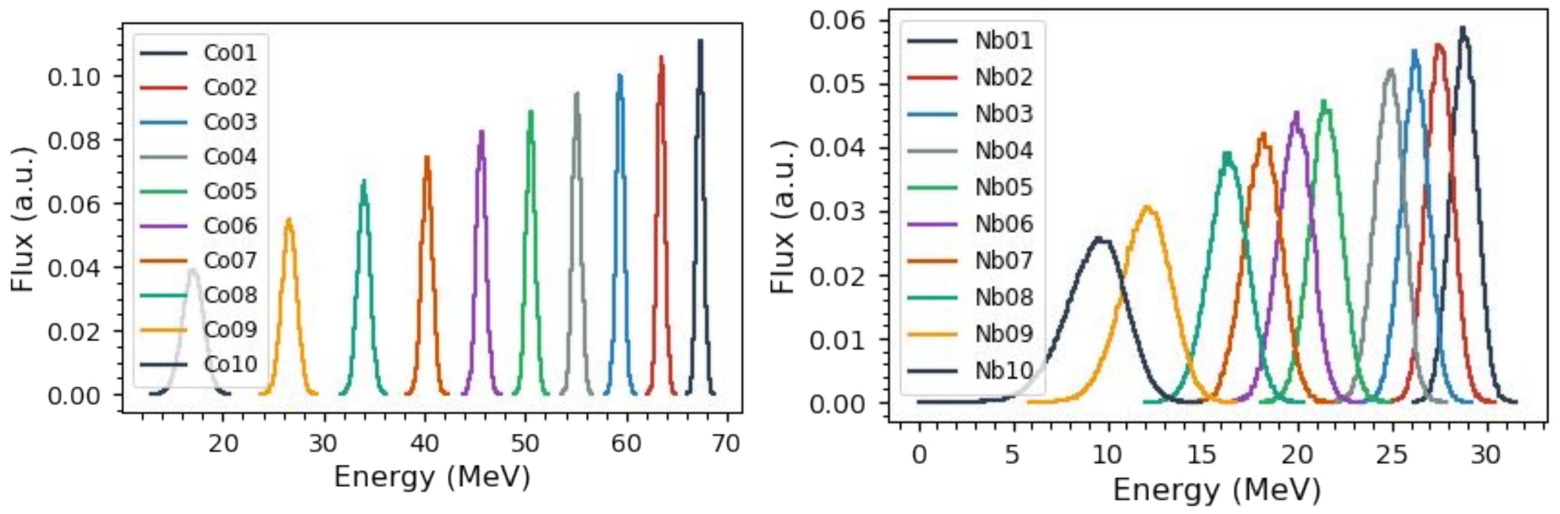
Target Stack Design

Target stacks consist of

- 1/16" thick aluminum holders for foils
- 1.0"x1.0" target (Co, Nb) and monitor foils (Al, Cu) secured to each holder with Kapton tape
- 1/16" thick aluminum degraders
- Aluminum case to attach each foil holder and degrader in the correct succession



Target Stack Modeling



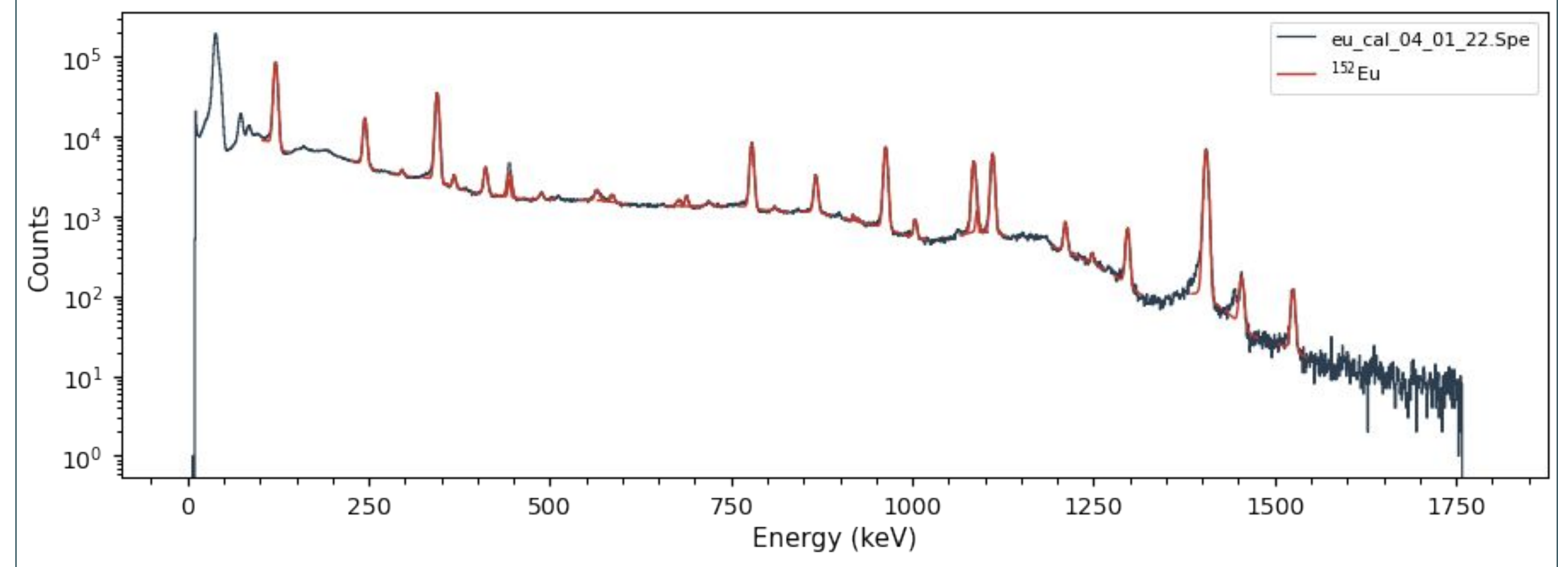
With the Curie python script developed by researchers at LBNL, we can model the entire stack of target foils, monitor foils, and degraders to plot the energy loss and flux through each of the target foils as the beam propagates through the stack. From this we can determine the number of degrader foils needed to ensure data points in the energy regions of interest.

HPGe Post-Irradiation Activity Analysis

Activity Analysis

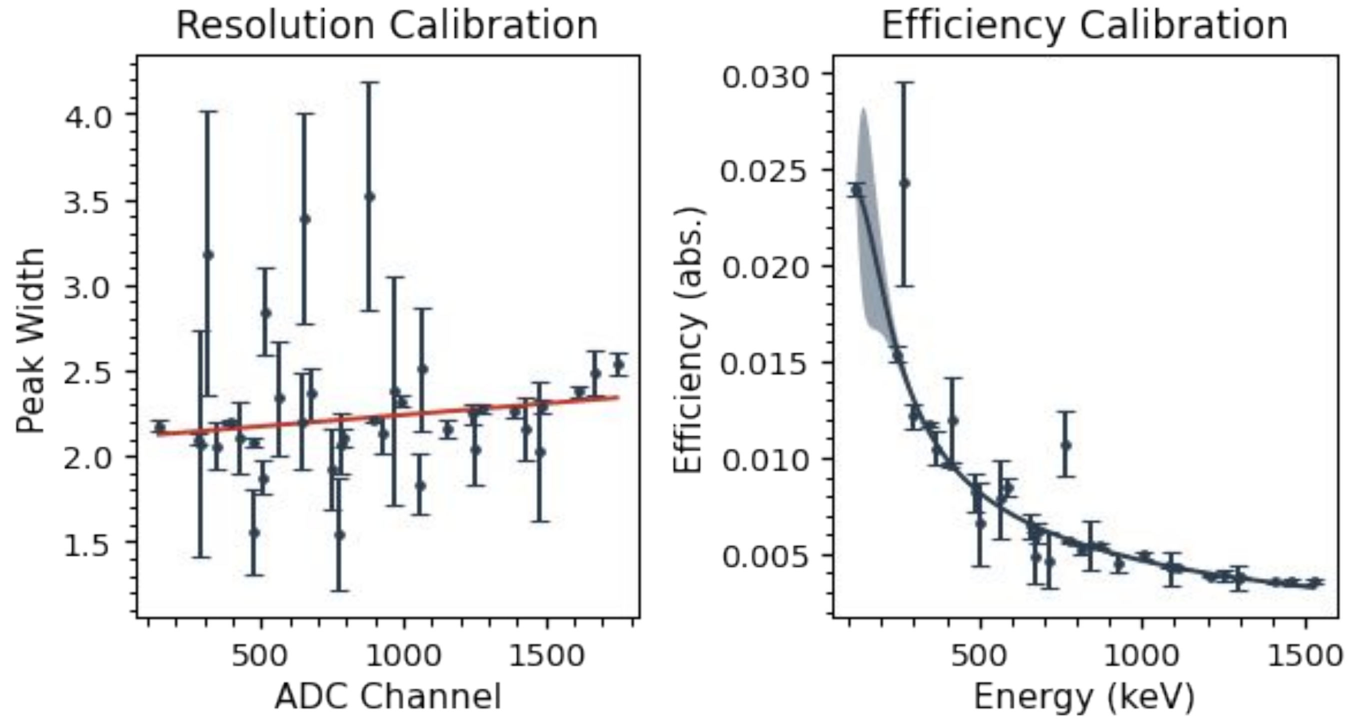
To calculate the cross section we must evaluate the activity of each of the foils post-irradiation. This is accomplished using a High Purity Germanium Detector (HPGe), which will measure the counts per second of emitted gamma rays of each foil, allowing for the extrapolation of the activity of the foil.

A spectrum for the ^{152}Eu calibration source is shown in the figure below, generated by the Curie software.



Detector Resolution and Efficiency

Critical to the evaluation of the activity is understanding the detection efficiency of the HPGe detector. Using the calibration source ^{152}Eu with a known activity, we can develop a function for the efficiency of the detector across the full energy range, as well as peak resolution.



Future Work

Upon completion of these cross section measurements for the ^{59}Co(p,3n)Ni^{57} and ^{93}Nb(p,n)Mo^{93} reactions we intend to:

- Explore additional cross sections with a particular focus on deuteron-induced reactions
- Compare results with the nuclear modeling code TALYS

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National Nuclear Security Administration