Silicon characterization in preparation for measurement of ^{60}Fe photon strength function

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^{60}Fe is a neutron-rich isotope of iron produced at a branch point in slow neutron capture (s-process) nucleosynthesis that holds astrophysical importance through the detection of its gamma rays in the interstellar medium. Despite its 2.5 million year half-life, it has been measured deep in the ocean crust [1], in Antarctic snow [2] and on the moon [3] indicating that this isotope is being actively produced in the nearby universe. The photon strength function (PSF) describes how probable the emission of a gamma ray would be from an excited state in a nucleus and is important for calculating neutron capture cross-sections [4]. By determining the PSF, we can place constraints on astrophysical models used to calculate the production and abundances of these neutron-rich isotopes produced in nucleosynthesis. An experiment has been proposed to measure the PSF for ^{60}Fe and testing of the experimental setup has begun.

For the measurement of the PSF we will use a beam of ^{59}Fe at 7.5 MeV/u separated using MARS and impinge it on a CD_2 target to produce ^{60}Fe in an excited state through a (d,pγ) reaction allowing us to mirror the direct neutron capture reaction. For the purpose of testing our experimental design and detector response, two test runs have been performed using a beam of ^{57}Fe at 7.5 MeV/u resulting in the $^{57}Fe(d,p)^{58}Fe$ reaction. In the first test run, an S3 annular silicon detector (wafer 2790-01), a CD_2 target, a PPAC and four BaF_2 detectors were used. The second test run added another 15 BaF_2 to the setup. A schematic of the second test run is shown in Fig. 1. For the purpose of this annual report, the performance of the silicon detector will be the focus.

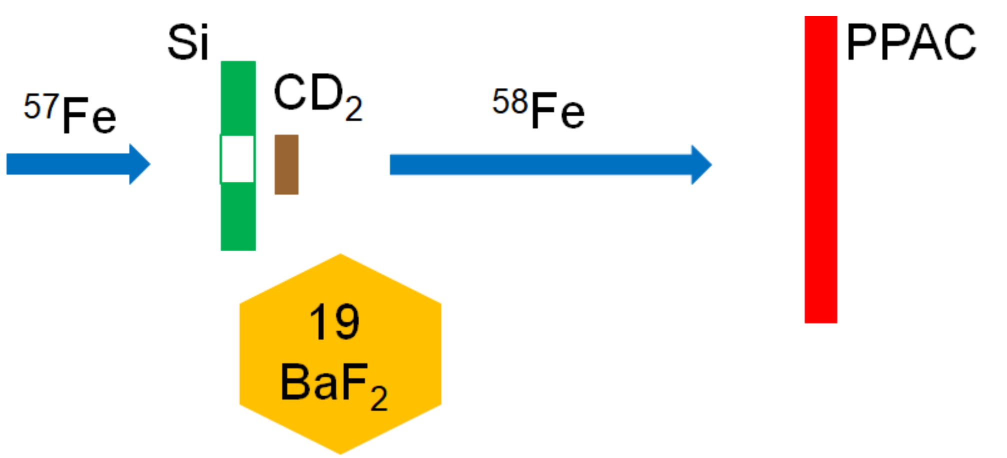

Fig. 1. Schematic of the test run setup.

The Micron S3 annular silicon detector serves to detect and measure the energy of the emitted proton from the (d,p) reaction. The 24 rings and 32 segments on the detector give position sensitivity which is used to calculate the excitation energy of the resulting ^{58}Fe nucleus. The detector covers the angular range of approximately 120-150 degrees. Fig. 2 shows the measured proton energies as a function

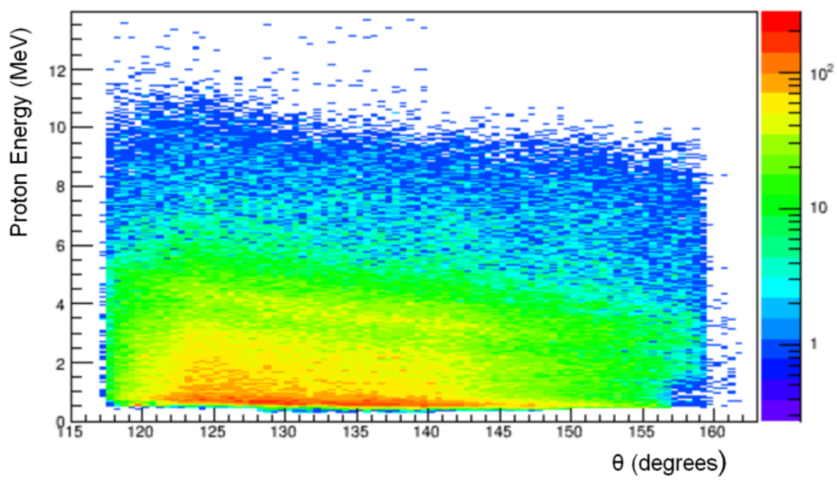

Fig. 2. Measured proton energy as a function of theta. The band indicates a particular excited state in ^{58}Fe.

of the angle of the emitted particle. The bands in the plot indicate specific states populated in the (d,p) reaction. This is then used to calculate the excitation energy of the nucleus as a function of the emitted proton angle which is shown in Fig. 3. This calculation currently only includes corrections due to the beam spot position on the target.

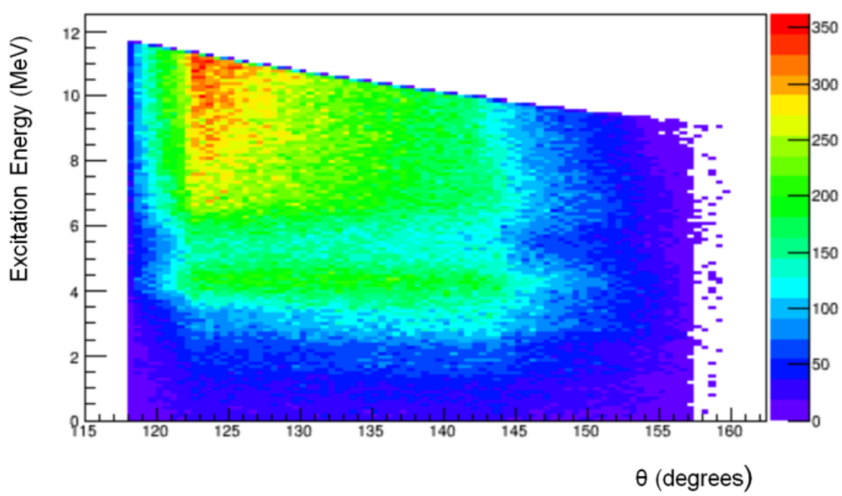

Fig. 3. Excitation energy of ^{58}Fe as a function of emitted proton angle.

We can take a projection of Fig. 3 and apply a multiplicity one and segment gate condition whereby we require only a single event to have occurred and take the ring spectra with respect to one particular segment that fired. This is plotted in Fig. 4. By doing so, hints of known states in ^{58}Fe are observed at 810 keV and 1674 keV, the first and second excited states. Corrections to the energy loss through the target are the next step in the analysis and are expected to improve the measured proton energies.

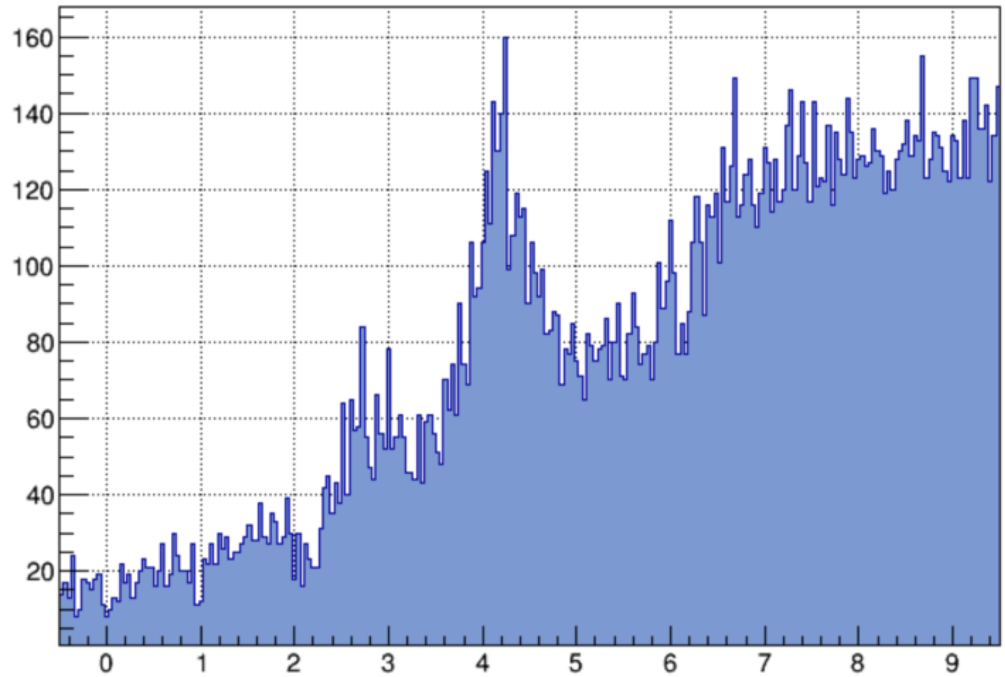

Fig. 4. Plot of the yield of calculated 58Fe residue excitation energy from the measured proton energy. Peaks in the 800 keV and 1600 keV range indicate the location of the first and second excited states of the nucleus.

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