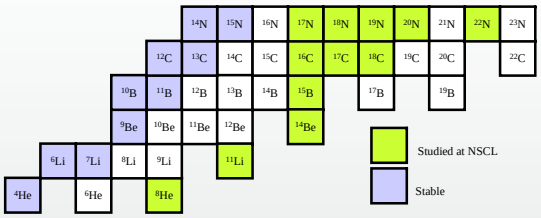
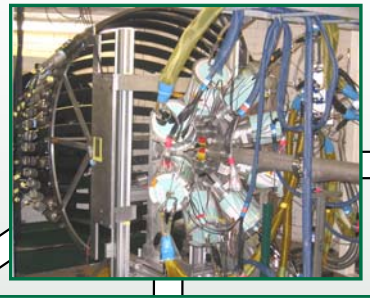
Study of Beta-delayed Neutron Emission at the NSCL

Name



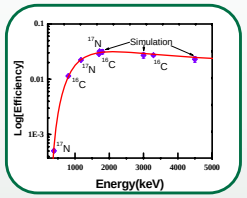
Studies of beta-delayed neutron emission conducted at the NSCL have focused on the lighter elements that are shown in green. Detailed experimental information on the beta-decay properties of nuclei far from stability are important because they can,

(a). provide crucial test of the validity of structure model calculation
(b). lead to the refinement of the interaction in the structure model
(c). be use in the astrophysical network calculations



The interested radioactive beam are produced in a pulse mode at the NSCL facility and implanted on a scintillation detector, called implantation detector, to monitor beta decay events. The experimental setup consists of an implantation detector system, neutron bar array and Segmented Germanium detector Array (SeGA).

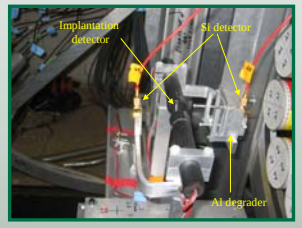
Neutron Bar Array



Neutron Efficiency Function

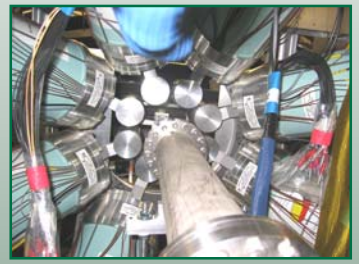
Neutron bar array consists of 16 plastic scintillator bars with the following specification.
Bar dimension: 157cm × 7.6 cm × 2.54 cm
Total solid angle: 1.9 steradians
Total time resolution: 2.4 ns for 1.8 MeV neutrons
Total position resolution: 13 cm
The implantation detector is placed in the center of the array where the radius of curvature is about one meter. Neutron array is calibrated for energy and efficiency using known beta-delayed neutron emission measurements from ^{16}C and ^{17}N decays. The efficiency curve for the array is shown with three simulated efficiency data points.

Implantation detector system

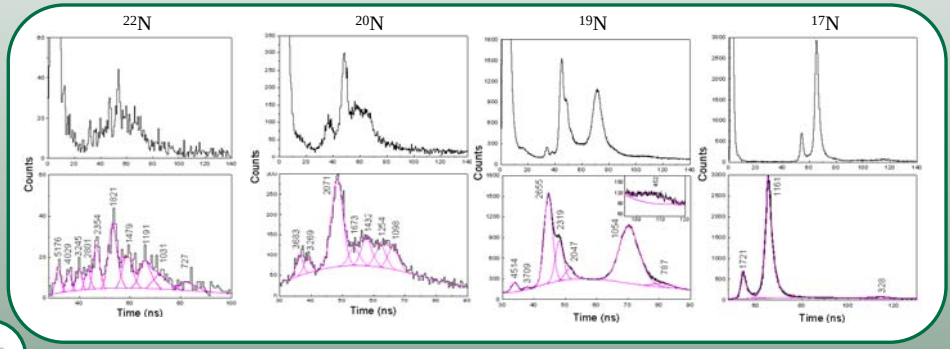


A secondary radioactive beam stops in the implantation detector, which produces a start signal to the neutron time-of-flight and gamma coincidence measurements with the detection of beta decay. The silicon detectors provide on-line data regarding yields and purity of implantation.

Segmented Germanium Array (SeGA)

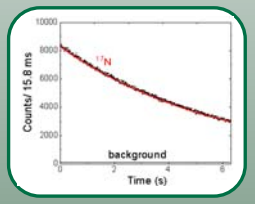


Beta-neutron Coincidence Time-of-flight Spectra

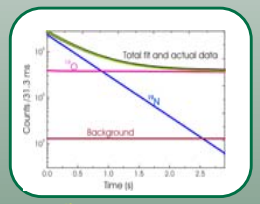


The beta-delayed neutron energy spectra are produced based on time-of-flight measurements and used to obtain the neutron emission probabilities for the neutron energy groups. The neutron energy spectra obtained from neutron array for ^{22}N, ^{20}N, ^{19}N and ^{17}N beta decay are shown with fitted asymmetric gaussian neutron peaks and a polynomial background. Neutron energies are shown in keV for each spectra.

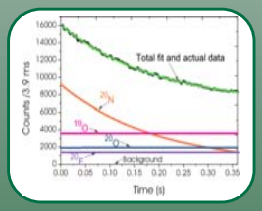
Half-life measurements



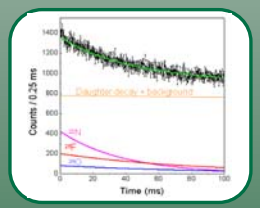
^{20}N Half-life = 4.17 s



^{19}N Half-life = 338 ms



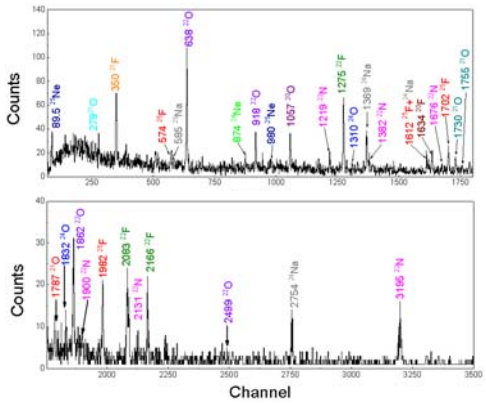
^{20}N Half-life = 133 ms

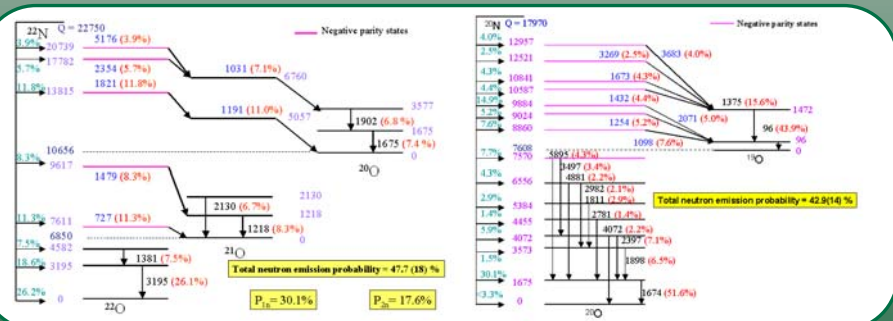


^{22}N Half-life = 25.8 ms

The implantation detector monitors beta decay events of implanted nuclides during the beam off time interval in conjunction with real time clock to produce decay curve. The ungated decay curve is fitted with suitable model to extract the half-life and the total number of decay events relevant to the interested nuclide. The results of half-life measurements for ^{17}N, ^{19}N, ^{20}N and ^{22}N are shown with the decay curves.

Beta-gamma Coincidence Spectrum – ^{22}N Beta Decay





The information from neutron and gamma spectra with total number of beta decay events can be used to produce the decay scheme. The preliminary decay schemes of ^{22}N and ^{20}N are shown. The neutron and gamma energies are given in blue and black respectively with their percentage emission probabilities in parentheses. Beta decay strengths to energy levels are shown in green.

Eight SeGA detector are placed in ring structure closer to the implantation detector to collect beta-gamma coincidence spectra. Gamma energies of the beta decay daughter provide beta decay strengths to neutron-bound states of daughter, while gamma transitions of the beta-delayed neutron decay daughter produce information on the decay strength of the excited states following the beta-delayed neutrons. Information on gamma energies of the grand daughter provides indirect measurement to the total neutron emission probability. The coincidence gamma spectra of ^{22}N are shown. The peaks are labeled with energies (keV) and the parent decay mode.

Studies using neutron array

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The NSCL is funded in part by the National Science Foundation and Michigan State University.