Michael Thoennessen

Professor and Associate Director
for Education
Experimental Nuclear Physics

M.S., Physics,
University of Cologne,
1985

PhD, Physics,
SUNY Stony Brook,
1988

Joined NSCL
in November 1990

thoennessen@nscl.msu.edu

Selected Publications

Discovery of exotic nuclides ^{40}Mg and ^{42}Al suggests neutron dripline slant towards heavier isotopes, T. Baumann *et al.*, Nature **449**, 1022 (2007)

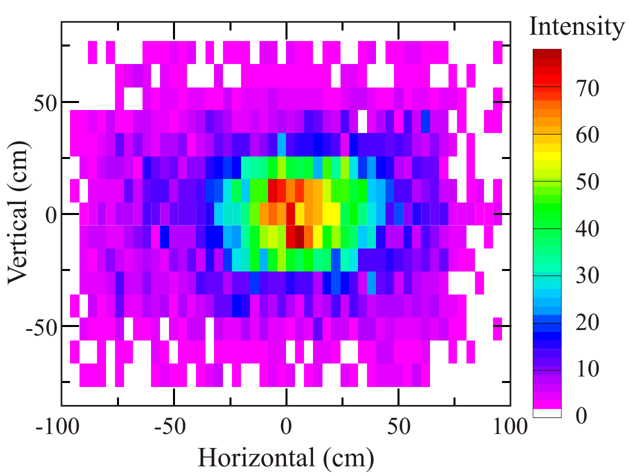
Selective Population and Neutron Decay of the First Excited State of Semi-magic ^{23}O, A. Schiller *et al.*, Phys. Rev. Lett. **99**, 112501 (2007)

First Observation of ^{60}Ge and ^{64}Se, A. Stolz *et al.*, Phys. Lett. B **627**, 32 (2005)

Construction of a Modular Large-Area Neutron Detector for the NSCL, T. Baumann *et al.*, Nucl. Instr. Methods **A543**, 517 (2005)

Reaching the Limits of Nuclear Stability, M. Thoennessen, Rep. Prog. Phys. **67**, 1187 (2004)

My research begins where the nuclear chart ends. While normal neutron-rich nuclei decay by converting a neutron into a proton (β decay) on a time scale of milliseconds or longer, nuclei beyond the end of the nuclear chart, or neutron-unbound nuclei, contain so many neutrons that they decay by emitting one or two of the excess neutrons on a time scale of 10^{-21}s. I am part of the MoNA/Sweeper collaborations which specialize in the study of these neutron-unbound nuclei. The masses and lifetimes of these extremely shortlived nuclei cannot be measured with standard techniques. The availability of fast radioactive ion beams at NSCL gives us the opportunity to create neutron-unbound nuclei and study them by detecting their decay products. For example ^{25}O, the first neutron-unbound oxygen nucleus, was recently studied by our group. A primary beam of ^{48}Ca was accelerated to about 50% of the speed of light with the Coupled Cyclotron Facility and a secondary beam of ^{26}F was selected by the A1900 fragment separator. The ^{26}F interacted with a target where we were specifically interested in the one-proton stripping reaction which leads to ^{25}O. Instantaneously, ^{25}O then decays in the target into ^{24}O and a neutron. Due to the large incoming energy from both, ^{24}O and the neutron will leave the target essentially at beam velocity. Following the target are two devices which were specifically designed for these studies. The 4 Tesla superconducting "Sweeper" magnet deflects the charged decay fragment into a set of particle detectors that identify the ^{24}O fragments and measure their energies and angles. The Sweeper magnet was built at the National High Magnetic Field Laboratory at Florida State University in collaboration with NSCL.



Neutron hits distributed over the front face of MoNA. The intense distribution in the center is due to neutrons emitted from the decay of the neutron unbound nucleus.

The second device is MoNA, the Modular Neutron Array. It is a highly efficient large area neutron detector which measures the energy and angle of the emitted neutrons. It was constructed by a collaboration of primarily undergraduate institutions, and undergraduates continue to participate in the experiments and data analysis. From the energies and angles of the fragments and neutrons, it is possible to reconstruct the mass of the neutron-unbound nuclei. ^{25}O is only one example of the many neutron-unbound nuclei at the limit of nuclear existence, and our experiment was the first to identify this exotic nucleus. With the exception of the lightest elements (up to boron – and now ^{25}O), none of these nuclei have been explored. The combination of MoNA and the Sweeper with the fast radioactive beams is one of the few facilities in the world where these nuclei can be explored. In addition to the measurement of neutron-unbound nuclei, the setup is also ideal to search for more exotic decay modes for example di-neutron emission.