The 2023 **MoNA** Report

The MoNA Collaboration

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Contents

Preface

Reflecting on yet another busy and productive year for the Collaboration, one highlight was the submission of an MRI proposal to build a next-generation neutron detector to expand the Collaboration's capacity for studying neutron-unbound systems. Led and written by Thomas Baumann, this milestone comes on the twentieth anniversary of the first MoNA detectors arriving for assembly. That construction effort was largely carried out by students and PIs at primarily undergraduate institutions. Twenty years later, more than 250 undergraduate students have worked on MoNA-related projects, and the Collaboration continues to add to that number as the MRI proposal, if funded, will again involve the efforts of undergraduate institutions in constructing the new detectors. The Collaboration was fortunate to welcome two new PIs: Belen Monteagudo from Hope College joined in August 2022 and Aldric Revel, MSU/FRIB, joined in July 2023. The second FRIB PAC approved two MoNA experiments to use Coulomb breakup reactions to probe the neutron configurations, separation energies, and geometrical information for ^{34}Na (a possible neutron halo nucleus) and ^{37}Mg (evidenced to be a neutron halo nucleus). This is an impressive feat given the competitive selection process – only 35% of the 11,859 requested facility-use hours were approved. Congratulations to Belen and Aldric for their work preparing the proposals. This brings the total number of approved FRIB-era MoNA experiments to four. The Collaboration continues to work towards running its first experiments at FRIB. Tasks include redesigning the Sweeper drift chambers and time-of-flight detectors to improve particle identification capabilities. Meanwhile analysis efforts continued for the last MoNA experiment at NSCL and the 2019 and 2022 neutron scattering measurements at LANSCE. July 2023 saw a trip to LANSCE to prepare for another measurement using diamond detectors to study neutron scattering on carbon. All of these activities will ensure a busy and exciting year for this Collaboration of outstanding scientists.

Thomas Redpath, Virginia State University
Executive Director, the MoNA Collaboration
FRIB, East Lansing Michigan, August 7–8, 2023

1 Introduction

The exploration of the limits of stability and the observation of new phenomena in nuclei far from stability has been identified as one of the key science drivers for a next generation U.S. facility for rare-isotopes [1]. The first step following the discovery of new isotopes is the study of fundamental properties, for example, masses, binding energies, and lifetimes.

At the very extreme of neutron-rich nuclei, the nuclei beyond the dripline are very short lived and can only be studied by reconstruction based on information gathered from their decay products. Also, nuclei close to the neutron dripline have no or only a few bound excited states, so that traditional γ-ray spectroscopy cannot be applied. However, these states can be explored by neutron–fragment coincidence measurements. Reactions on such exotic nuclei reveal dynamical nuclear properties such as new preferred modes of excitations. When such reactions involve neutrons they are often of interest for explosive astrophysical scenarios. The most efficient and economical way to produce and perform experiments on these nuclei is with rare isotopes produced by high-energy projectile fragmentation. In order to reconstruct the decay energy spectrum, a magnet to deflect the charged fragments and a highly efficient position sensitive neutron detector are necessary.

The Modular Neutron Array (MoNA) was constructed and is operated by a unique collaboration of primarily undergraduate physics departments in partnership with Michigan State University. It has already involved more than 250 undergraduates from over 25 colleges and universities in nuclear physics experiments. The MoNA collaboration is poised to play an important role in educating the next generation of nuclear physicists. This paper outlines the importance of the physics which MoNA can do at a fast fragmentation facility and the potential role of the collaboration in educating future nuclear physicists.

The publications and presentations that detail the results obtained by the collaboration can be found in Section 7. Also cataloged are the students that have benefitted from work with the device in Section 8. A summary of the systems studied is shown in Figure 1.

2 Physics With MoNA

2.1 Results and Perspectives

Nuclear structure and reactions at and beyond the dripline

Along the neutron dripline where the neutron binding energy becomes zero, the relatively small enhancement of the total binding energy for paired neutrons has an important effect. The stability of nuclei with even numbers of neutrons N compared to their neighbors with odd numbers creates a saw-tooth pattern in which the heaviest odd-N isotopes of a given element are neutron-unbound, while heavier isotopes with an even number of neutrons can be bound. Well-known examples are ^{10}Li (unbound) and ^{11}Li (bound), or ^{21}C (unbound) and ^{22}C (bound). The properties of the alternating neutron-unbound nuclei provide important insights into the neutron–nucleus interaction far from stability, the coupling to the continuum in neutron-rich systems, and the delicate structure of multi-neutron halos or skins. In addition, the wave functions of the even-N nuclei at the dripline are not well known, and studies of the adjacent neutron-unbound (odd-N) nuclei can yield single-particle information crucial for the characterization of the heavier bound nuclei.

Properties of neutron-unbound nuclei

Intense fragment beams of the most exotic bound nuclei have been used at the National Superconducting Cyclotron Laboratory (NSCL) and elsewhere to extend mass determinations from reaction Q-value measurements to neutron-rich nuclei beyond the dripline, where the ground state is an unbound resonance. In a typical experiment, the energies and angles of the neutron and the fragment from the decay of the unbound parent nucleus must be detected with sufficient precision to allow reconstruction of the energies of the resonant states. The observed decay energy determines the mass while the width of the resonance is related to the angular momentum of the state. Just as for traditional transfer reactions, different reaction channels provide complementary information, and both proton and neutron removal reactions are important and necessary to populate the neutron-unbound states. Nuclear masses and angular momenta of ground-state wave functions of unbound nuclei provide information on the shell structure at the neutron dripline that cannot be obtained by other means.

Neutron-unbound excited states

Neutron-unbound excited states of bound nuclei can be populated either in nuclear breakup reactions via excitations from the ground state or via particle removal reactions from neighboring nuclei.

Breakup reactions where the nucleus is excited via the nuclear or Coulomb interaction are versatile tools to study continuum properties. For example, Coulomb-breakup of halo nuclei is mostly sensitive to the s-wave component of the ground-state wave function and hence will be able to provide a spectroscopic factor for a core $\otimes$ $s_{1/2}$ configuration in the ground state of the nucleus of interest [2]. Such measurements could be precision tests of results from the more common knockout or transfer reactions, since the reaction mechanism of Coulomb breakup is better understood theoretically.

Several interesting quantities are accessible by particle removal reactions. For one, the energy and decay path of resonances are of interest for nuclear structure. Also, high-lying first excited states are indicative of gaps in the single-particle level scheme and suggest new magic numbers. The energy of resonances can shed light on the

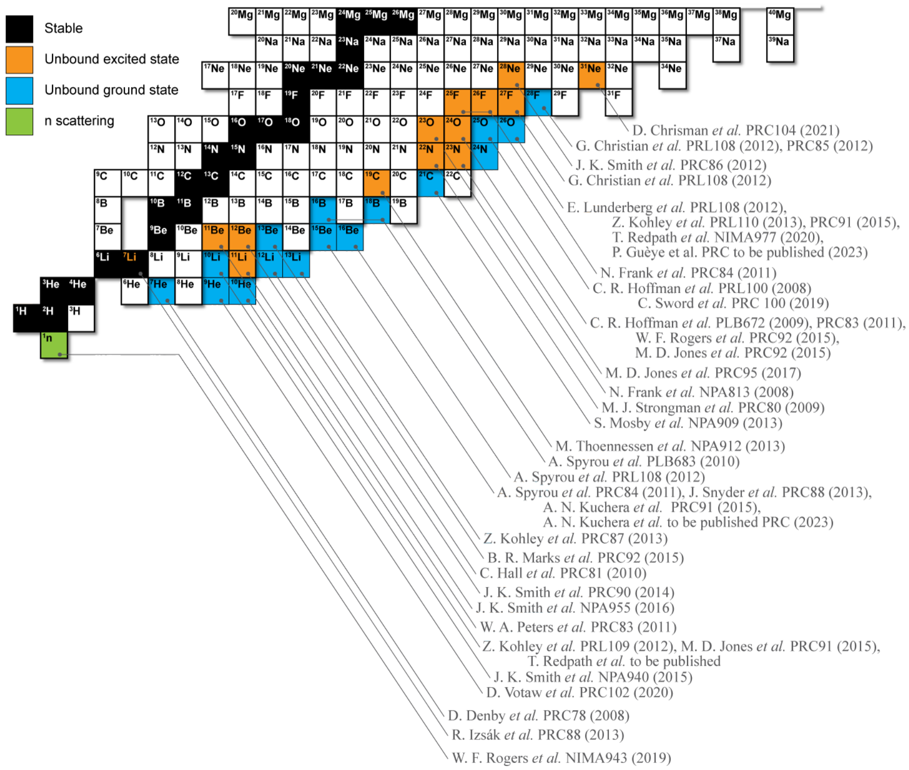

Figure 1: A portion of the chart of the nuclides showing collaboration measurements.

role of the continuum in nuclear structure at the dripline. Moreover, particle-removal cross sections to resonances yield spectroscopic factors, which can again be compared with theory.

Neutron Halos

Weakly bound few-body systems have been found to exhibit properties such as halo structures, which are very different from those of well-bound systems. The study of these neutron halos is important for a better understanding of nuclear structure close to the dripline and also helps to understand the universal features of weakly bound few-body systems in general. For example, halo structures are also found in atomic and molecular systems [3, 4]. Close to the neutron dripline, a number of nuclei have been found to exhibit neutron halos [5], and many more are predicted to exist [4].

When the last neutrons in a nucleus are weakly bound and have predominant *s*-wave character, the absence of a confining Coulomb and angular-momentum barrier allows the extension of the neutron wave function far beyond the nuclear core via quantum-mechanical tunneling. The attraction of the nuclear potential is weak in this extended region and, as a result, the nucleus develops a diffuse halo with one or a few neutrons distributed over a large volume. The radial wave function of such a halo depends critically on the neutron separation energy. Thus, precise measurements of nuclear masses and separation energies of these exotic systems provide important information for theoretical descriptions as well as for the identification of new halo candidates.

2.2 Invariant Mass Measurements

The study of neutron-unbound systems using the Sweeper and MoNA-LISA devices are based on the well-established technique of invariant mass measurements. Determining the population of unbound states in nuclear reactions through knock-out, breakup, or transfer reactions, followed by detection of all of the decay products in coincidence, *i. e.* the neutron (or neutrons, indexed n) and the charged fragment (indexed f), is necessary. Measurement of the energies (E_n and E_f) and momentum vectors ($\vec{p}_\mathrm{n}$ and $\vec{p}_\mathrm{f}$) of the involved particles enables the reconstruction of the invariant mass or the decay energy (see Figure 2). The decay energy E_d is the invariant mass of the unbound system minus the sum of the separate particles' masses and for one-neutron decay is given by:

$$E_\mathrm{d} = \sqrt{m_\mathrm{f}^2 + m_\mathrm{n}^2 + 2(E_\mathrm{f}E_\mathrm{n} - \vec{p}_\mathrm{f}\cdot\vec{p}_\mathrm{n})} - (m_\mathrm{f} + m_\mathrm{n})$$

These invariant mass measurements are performed with a large-gap dipole magnet or "Sweeper" that separates the unreacted beam, charged reaction products, and neutrons in such a way that the forward-going undeflected neutrons are cleanly detected in a high-efficiency neutron detector such as MoNA-LISA (see Figure 2).

2.3 NSCL Studies

The MoNA collaboration has performed an experiment (e16027) to look at neutron unbound excited states in the

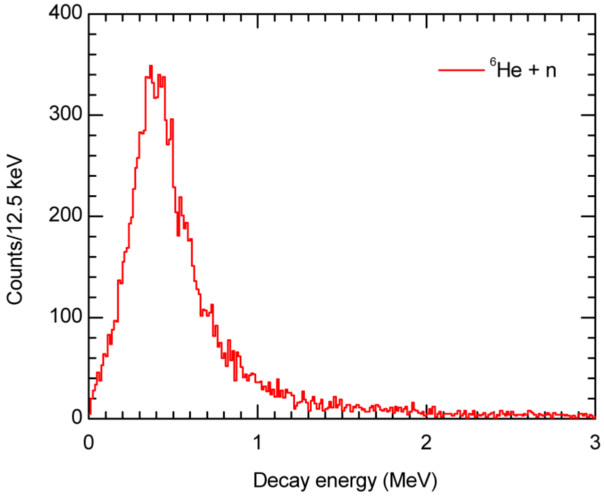

Figure 2: The reconstructed decay-energy spectrum for the neutron-unbound ground state in ^{7}He, which is unbound by 450 keV and which has a width of 160 keV. The data were taken during the commissioning of the Sweeper Magnet and the MoNA neutron detector at NSCL.

Figure 3: Robbie Seaton-Todd (Davidson College) doing inter-layer time matching at the NSCL.

N=20 island of inversion. The experiment used a ^{33}Mg beam and focused it onto the segmented target in attempt to reconstruct the decay energies. The analysis has been performed with members from Davidson College, Hope College, Augustana College, and Michigan State University. Currently decay energies are being finalized and simulations are beginning. Figure 3 is a picture of a Davidson College student, Robbie Seaton-Todd, who participated in the experiment at NSCL and has worked on the analysis both summer 2018 and 2019.

The MoNA Collaboration is in the process of analyzing data from experiments e14014 (thesis experiment of H. Liu) and e15091 (thesis experiment of D. Votaw) in order to investigate shell evolution in the N=7,8 region. These experiments aim to selectively populate states in ^{9}He, ^{10}He, and ^{10}Li. All three of these unbound systems are interesting test beds for the evolution of nuclear structure far from stability, and can shed some light on the formation of exotic structures, like the 1- and 2-neutron halos of ^{11}Be and ^{11}Li respectively. It has even been suggested (by K. Fossez, et al. [6]) that the 2n-unbound ^{10}He may have a "double halo" structure, where the 2n-halo nucleus ^{8}He has an additional 2n halo. e15091 is a search for the controversial s-wave ground state resonance of ^{10}Li and ^{9}He, in order to confirm or refute parity inversion in the neutron-unbound N=7 isotones. e14014 is an investigation of the reaction mechanism dependence of the observed ^{10}He resonance. Both experiments were successfully run at the NSCL, and the data analyses are nearing the end. Manuscripts describing the results are currently in preparation.

The MoNA Collaboration is in the process of analyzing data from experiment e19013 (thesis experiment of X. Wang). Past experiments have identified a resonance at a decay energy of 500 keV and that of Kondo et. al. [**?**] assigns it to be a ½ minus level in 13Be. Generally, one might expect that this state would be a low-lying state that decays to the ground state but it is possible that this first p state is above excited states in 12Be. In particular, no experiment has looked for gamma rays in coincidence with this resonance. It is important to note that the first excited 0+ state, the most likely spin parity combination for the child level, is a long-lived isomeric state and so the gamma rays that would locate the 13 Be level would be emitted from 12Be in the fragment detector rather than the target

This was the Collaboration's final experiment with the Coupled Cyclotron Facility. It was a "Sweeper-less" experiment, meaning that the Sweeper magnet that is usually used for invariant mass measurements was not used. Not only did this experiment (e19013, Paul DeYoung, Hope College) look for neutron unbound states in ^{13}Be, it will also shed light on isomeric states in the daughter nucleus, ^{12}Be, which complicates the invariant mass measurement of ^{13}Be if not detected. This measurement made use of the Modular Neutron Array (96 of the possible 288 bars), employed the gamma-ray detector CAESAR, and featured the newly developed charged particle telescope. The new charged particle telescope was developed by Prof. Nathan Frank of Augustana College in Rock Island, IL was used for particle ID. This new telescope will have the enhanced resolution needed to push the invariant mass measurements to heavier neutron-unbound systems that will become accessible with future FRIB beams. In addition to new detectors, the signals were recorded with new acquisition. A Digital Data Acquisition System (DDAS) was used for recording traces from CAESAR and the charged particle detector tele-

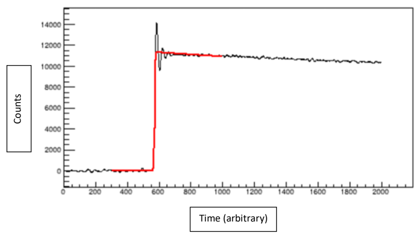

Figure 4: The histogram above is a recorded trace from experiment 19013 of one of the SiPIN detectors using a fit first developed by Ron Fox at the NSCL/FRIB and refined by Augustana students Georgia Votta and Henry Webb. Each trace has a range of 10 microseconds with a binning set by DDAS.

scope. Trace fitting is superior to the parameters resulting from DDAS's internal algorithms for determining the energy deposited by charged particles. Fig. 4 shows a sample trace for one of the SiPIN detectors, which shows a typical trace. The trace fitting algorithm developed within the collaboration includes various corrections and identification of double pulses due to two secondary beam particles entering the detector within a 10-microsecond range of the trace.

Calibrations of all the detectors, time and energy, have been done. Preliminary decay energy of 13Be and gamma spectrum with proper event selection have been made. The current stage of analysis is to further refine those spectra in order to extract reliable physics interpretation. A new CAESAR addback algorithm featuring multiple cluster finding has been developed to handle Compton scattering of multiple gamma rays in one event

2.4 FRIB PAC 1 Experiments

One of the MoNA Collaboration's two PAC-1 approved experiments will attempt to measure neutron unbound excited states of ^{53}Ca at FRIB. The predicted levels for neutron unbound excited states are within the capabilities of the MoNA Collaboration to access and measure via invariant mass spectroscopy. Studying ^{53}Ca provides a unique opportunity to study the impact of neutrons on the nucleus due to the magic number of protons (Z=20). Additionally, suggestions of new emerging neutron magic numbers at N = 32 and 34 provide the opportunity to collect experimental data within this region. ^{53}Ca will be the heaviest nuclei the MoNA Collaboration will attempt to date. Measurements within this realm can aid in the theoretical calculations and predictions where the neutron drip-line lies from the data collected. In particular, the $3/2^+$, $5/2^+$, and $9/2^+$ calculated excited states are of interest with the $9/2^+$ presenting a narrow resonance band which can provide a narrow peak in an energy-decay spectrum as shown in Fig. 5. If the unbound excited states are measure to be located as predicted by theory, it can lead to the development of ab initio coupled-cluster cal-

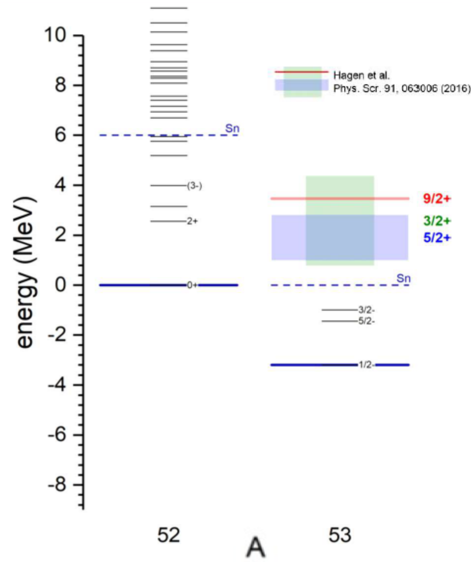

Figure 5: ^{53}Ca level scheme.

culations/citehagan2016emergent for understanding, determining, and predicting the structure of heavier nuclei as one moves up the chart of nuclides while using ab initio methods.

The second of the two PAC1-approved experiments is "First Observation of Neutron-Unbound ^{30}F", (PI Calem Hoffman, e21016). While ^{30}F has been presented in conference proceedings, no experimental data has been published on the nuclide. Virtually nothing is known about ^{30}F except that it is neutron-unbound. ^{30}F resides at the southern shore of the island of inversion. One of the primary objectives of the experiment is to determine the energy of the ^{30}F ground state. One implication of this is insight into the ordering of the $\nu 1p_{3/2}$ and $\nu 0f_{7/2}$ orbitals, which could potentially explain the structure of ^{31}F. The bound nature of ^{31}F may be due to a lowering of the $\nu 1p_{3/2}$ orbital (below the typically lower energy $\nu 0f_{7/2}$ orbital), or it may be due to one or more of the following: continuum coupling, three-body forces, or deformation. A secondary goal of the experiment is extraction of energies and characteristics (J^{π}, intrinsic widths, decay paths and branching) of the low-lying excited levels in ^{30}F. Other opportunities exist in the other isotopes contained within the beam composition, including ^{31}Ne (single neutron knockout), ^{32}Na (single proton knockout) that can be used to study neutron unbound states within ^{30,31}Ne. These states can be used to probe the ^{31}Ne neutron-halo nucleus complementary to the available studies.

The experiment will utilize a ^{48}Ca primary beam, which produces a secondary beam of ^{31}Ne at 130 MeV/u after impinging on a ^{9}Be production target. The ^{31}Ne will then impinge onto the segmented target, producing ^{30}F in a single proton knockout reaction. The experiment will feature the typical MoNA setup, which includes the MONA-LISA neutron detectors, the Sweeper magnet, the Sweeper charged particle detectors, and the CAESAR gamma ray detectors. To prepare for the experiment, the CRDCs are being replaced with new Drift chambers to improve their performance, and the ToF start and stop detectors are being replaced to improve their resolution.

2.5 FRIB PAC 2 Experiments

Two experiments of the MoNA collaboration were approved during the FRIB PAC2. Those experiments aim to improve our understanding of the formation of neutron halos, which is a striking feature observed in some nuclei located in close proximity to the neutron dripline. Such systems can be described as valence neutron(s) extending far outside a core and can only exist if two conditions are satisfied: a weak binding of the system and the valence neutron(s) being located in low-ℓ orbitals (ℓ=0,1). One can also notice that the vast majority of known or suspected to be halo nuclei are located below $Z = 8$. Beam intensities provided by FRIB offer unique opportunities to investigate such phenomena in heavier mass systems. Both PAC2 approved experiments will shed light on the mechanisms responsible for the formation of halos in neutron-rich nuclei and in particular on the interplay between deformation, shell evolution, halo formation and coupling to the continuum.

The first experiment will investigate ^{37}Mg, the heaviest system in which experimental evidence of a neutron halo has been observed. The magnesium isotopic chain is of great interests as it extends from the $N = 20$ to $N = 28$ islands of inversion. Although those two regions were considered as separate from each other, results on ^{36}Mg and ^{38}Mg suggested that they are merging into a "big island of deformation". Study of neutron-rich magnesium isotopes might therefore provide important information on the complex mechanisms at play in this region.

The second experiment aim to investigate the possible halo configuration of the ^{34}Na nucleus. ^{34}Na is, such as ^{37}Mg, located within the big island of deformation and is weekly bound, making it a good candidate for the formation of a neutron halo, which is supported by theoretical calculations. In addition, this study will allow to determine neutron capture cross-sections which are relevant to the r-process near the neutron dripline.

Halo nuclei display interesting phenomena such as large interaction cross-sections, soft E1 excitation and narrow momentum distributions of the core fragment after breakup. The formation of a halo was found to be correlated to phenomena that include, amongst other, shell evolution and the development of deformation. In both experiments, the nucleus of interest, ^{37}Mg and ^{34}Na, will be studied using kinematically complete Coulomb breakup measurements in order to map the dB(E1)/dErel function and extract key information such as the geometrical information of the halo, the neutron separation energy, the ground state and its configuration mixing. The invariant-mass method will be used to reconstruct the relative energy following the Coulomb breakup reaction. The neutron will be detected by the MoNA-LISA array and the recoil fragment will be deflected by the sweeper magnet before being measured by a set of detectors. In addition, eventual excited core components will be revealed using the CAESAR CsI-array placed around the target.

2.6 Additional Analysis of Past Data Sets

The MoNA experiment e09067 was performed to make the first observation of the unbound nuclide ^{15}Be. This was done using a neutron pickup reaction with a ^{14}Be beam and search for decays by ^{14}Be+n. The observed state could not be confirmed as the ground state because of an alternate decay path through the first excited (unbound) state in ^{1}4Be which would decay by another two neutrons to ^{12}Be. To search for the predicted state lower than what was observed requires reconstructing ^{12}Be+3n. A re-analysis of e09067 has produced the 2-, 3-, and 4-body decay energy plots. The group at Davidson College in partnership with Augustana College is finalizing simulations and fitting those simulations to the data to search for the predicted ground state of ^{1}5Be. The MoNA Collaboration's research program has grown to include relatively novel studies of projectile fragmentation reactions. Two separate experiments, (e09096 and e12011) made exclusive measurements of neutrons in coincidence with isotopically identified products to compare neutron signatures to models that simulate collisions and reactions on nuclei. Comparisons depend on a wide range of reaction products from a single secondary beam in order to draw conclusions on trends. In addition, two other experiments (e12004 and e16027) have multiple secondary beams with many reaction products, which makes them possible inclusions with the analysis. This work will be led by a graduate student at MSU. The results have sparked discussion about neutron signatures and how they can inform relative populations and excitation energies of projectile-like fragments in beam-target interactions, participated in a larger discussion regarding how we interpret "neutron hit multiplicity."

2.7 Development of a Next Generation Neutron Detector

As MoNA is past the age of 20 years it is timely to look at new developments in detector technology and at the same time take a detailed look at the requirements for future experiments, in order to answer the question what a next generation detector could look like. While MoNA (and LISA) were mainly optimized for high neutron detection efficiency, this is not all that is needed. Resolution, discrimination capability, reliability, etc. are other factors to consider. Clearly, to achieve the best physics data, a balance between these design criteria has to be identified. New techniques in photon detection are available, and advanced electronics are already realized in other neutron detector arrays (NeuLAND and NEBULA). To answer the question where can the MoNA collaboration make an impact, detector simulations have been undertaken and prototypes are being constructed.

The new detector design aims at optimizing the position resolution for neutrons significantly by using a different approach in the light readout that employs an array of SiPM detectors. A test kit has been put together to investigate this approach and to benchmark simulation results. The test kit consists of a small scintillator bar that is fitted with two or four SiPMs (Fig. 6). It also includes a digitizer and SiPM bias supply, needed cables and other supplies, and testing is done at a number of MoNA institutions.

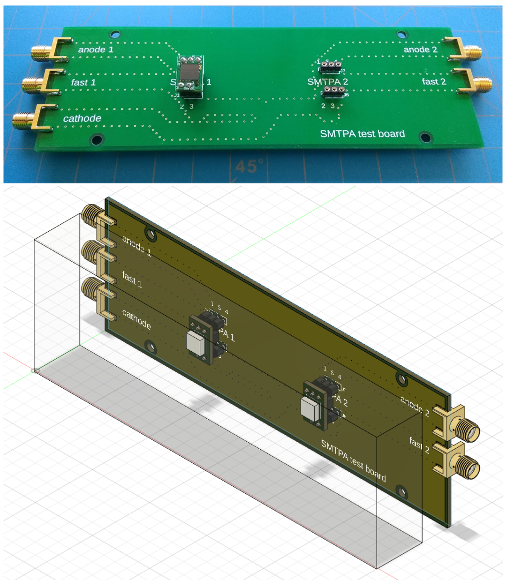

Figure 6: SMTPA test board to read out signals from a pair of SiPMs (one SiPM is installed, left) and assembly of small scintillation detector (right).

An MRI grant proposal to fund the next generation neutron detector has been submitted to the NSF by a consortium of 8 MoNA collaborators: MSU/FRIB (lead organization), Augustana College, Davidson College, Hope College, Indiana Wesleyan University, James Madison University, Virginia State University, and Wabash College.

The plan is to develop a detector array consisting of plastic scintillator tiles that are read out by SiPM sensors. The proposed detector array can be used as a stand-alone neutron detector, or in combination with MoNA-LISA in order to complement their detection capabilities.

2.8 Development of a New Charged Particle Detector Telescope

The most straight-forward type of experiment on exotic systems by the MoNA collaboration involves detecting a single neutron and charged particle resulting from a nuclide decaying from a neutron-unbound state.

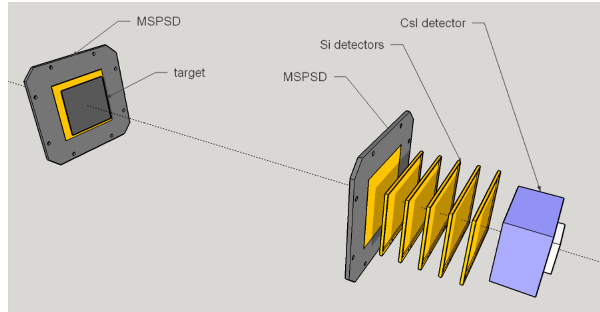

Figure 7: Components of the charged particle telescope. (Beam enters from the left.)

However, the charged fragment may be in a bound excited state resulting in gamma-ray emission, such as for some neutron-unbound states of ^{25}F and ^{13}Be. Thus efficient coincident detection of gamma-rays, neutrons, and charged particles is desired. A MRI grant proposal titled "MRI Consortium: Development of a Charged Particle Telescope by Undergraduate Research Students for Studies of Exotic Nuclei"(MRI-1827840) was written to purchase, develop, and install a compact Charged Particle Detector Telescope (CPDT) that will provide a balance of efficient gamma-ray, neutron, and charged particle detection. Figure 7 shows a schematic layout of the full experimental setup using the CPDT. The secondary beam passes through one silicon position-sensitive detector (140 μm thick), enters the reaction target, passes through another silicon position-sensitive detector (140 μm thick), and then a stack of Silicon detectors (500 μm thick) with a CsI crystal (3 cm thick) read out by a Silicon Photo Multiplier (SiPM). The energy loss measurements (silicon detectors) and the total energy measurement (CsI crystal) provide the charged particle identification for the system. The position-sensitive silicon detector (MSPSD) determines position using signals from a four-corner readout and determines energy loss from the cathode side. A separation of 50 cm is expected to yield 4 mrad resolution, which meets our requirements. The calibrated energy measurements will be added together to find the charged particle energy (total kinetic energy). This combined information will be used to calculate the charge particle's momentum for the invariant mass calculation. Testing of detector was performed at Augustana College. Characterization of detectors included verifying manufacturer specifications and determining any position-sensitive effects on electronic signals. This testing utilized a compact VME setup and a homemade raster scanner. This system was used in experiment 16027 (see Section 2.3) to detect the charged particle, allow the neutron to pass through with minimal attenuation to then be detected by the MoNA-LISA, and allow gamma-ray detection using compact systems already at the NSCL. Fig. 8 shows the particle separation from e16027 using the CPDT, which shows the particle separation capabilities in the compact setup. In addition,

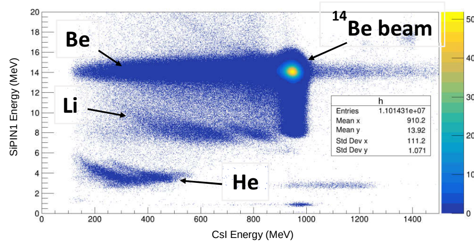

Figure 8: Components of the charged particle telescope. (Beam enters from the left.)

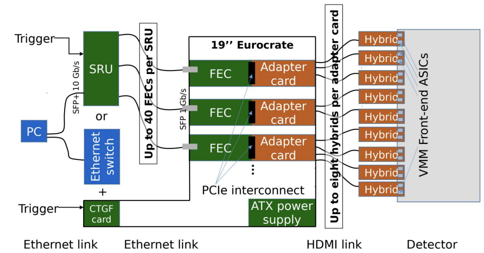

Figure 10: SRS Hardware is in green, ASIC hardware is in orange. From the figure, each hybrid can have 2 VMMs, and each FEC can support 8 hybrids. Every VMM has 64 channels.

this device will also be available for use at FRIB.

2.9 The Multi-layer 'Active' target for MoNA Experiments (MAME)

In order to alleviate the limited beam rate required to avoid deterioration of the silicon-based segmented target an alternative design using Gas Electron Multipliers (GEMs) technology is being developed (Fig. 9).

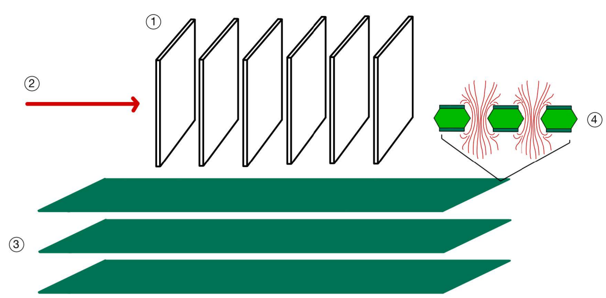

Figure 9: Drawing of the MAME concept. (1) Segmented target (2) Incoming beam (3) GEM foils (4) Zoomed-in side profile of the GEM foils.

GEM foils have been in use for around 20 years in many different kinds of detectors and were originally invented by Fabio Sauli in 1997 [**?**]. The basic mechanism is to place thin foils ($\sim 50\ \mu$m thickness) perforated with small holes ($\sim 70\ \mu$m diameter) in a gas with an applied electric field. Electrons are produced from ionization of the gas molecules when a particle passes through it which then drift to the anode. The electric field is stronger in the holes thus inducing an avalanche that can be repeated (e.g., multi-layered GEMs) and eventually reaches the XY readout strip plane located at the bottom of the stack.

One of the goals for the MAME target is the possibility to measure the energy loss and thus reconstruct the tracks of the produced fragments and recoils between each target segment, mimicking the previous design of the segmented target with Si.

The data acquisition to be used with MAME is based on the Scalable Readout System (SRS) (Fig. 10) which is a general channel readout developed in 2009, specifically designed to be able to scale to systems with a large number of channels [7, 8].

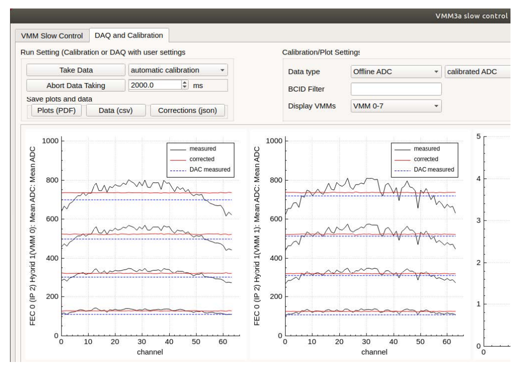

Figure 11: Screenshot of the Slow Control program, which is the software for the SRS, showing the results of the internal ADC offline test. This is a test of one Hybrid (so two VMMs: VMM0 and VMM1).

A first implementation of the GEM+SRS system was tested (Fig. 11). The full integration of SRS in the FRIB framework is ongoing. Once completed, plans are underway to perform additional tests on this prototype. In parallel, a CAD design is also being developed along with a dedicated Geant4 simulation.

2.10 Sweeper matrix optimization

The sweeper magnetic field has been recently modeled and compared to the measured map (see sweeper magnet section). An optimization algorithm is being developed to optimize the COSY matrix elements in order to improve the resolution of the decay energy spectrum (see Fig. 12).

2.11 Cherenkov Detector

Understanding the reaction mechanism is critical to gain insights about shell evolution as it can favor the population of particular states within the newly created isotope [9**?**]. FRIB (and in the future FRIB400) are increasing the energy of rare isotope beams from 100 MeV/u to 200 MeV/u (and eventually 400 MeV/u) making it more

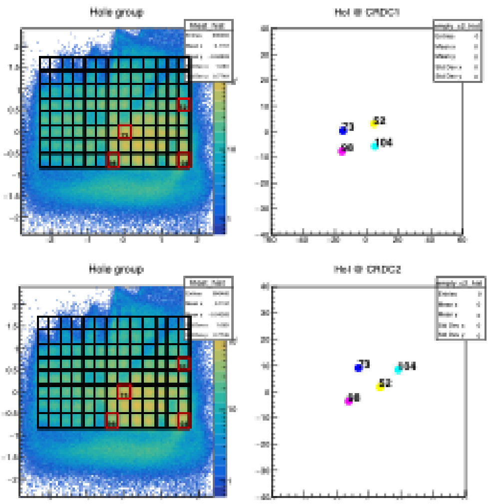

Figure 12: Optimization of the sweeper matrix elements showing the distributions of the mask holes on CRDC2.

Figure 13: The detector array geometry used in the first LANSCE experiment, consisting of 16 MoNA detectors arranged in two horizontal layers of 8 detectors each. The neutron beam entered the room through a 3-mm collimator, visible in the upper right corner of the picture, and impinged on the array at the center point of the first upper layer detector.

difficult to separate the outgoing fragments from the reaction target due to their very close velocities. Through a collaboration with the CNRS/CEMHTI Center in Orléans, France, a Cherenkov detector is being developed to complement the current energy loss vs. time-of-flight PID system.

2.12 Detector Characterization at LANSCE

Simulation of neutron scattering in MoNA-LISA provides a critical tool for the analysis of experimental data. In 2012 the collaboration published tests for two simulation GEANT4-based packages (G4-Physics, based on the JENDL library, and MENATE_R, based on n-H and n-C cross sections) for neutrons with energy 55 MeV/u [10]. In order to expand this study to much higher neutron energies, the collaboration transported 16 MoNA bars to the LANSCE facility at Los Alamos National Laboratory in order to place them in the path of a 10-800 MeV neutron beam. Observations of specific scattering observables could then be compared with simulation as a measure of its effectiveness over a broad range of energy. Two experiments were performed, each in the 90-m station at the LANSCE WNR facility on the 4FP15L flight path. The goal for both was to compare several neutron scattering observables with the same two Geant4-based simulation packages used in the previous study [10].

For the first experiment (LANSCE 1, January 2017) 16 MoNA bars were arranged in two horizontal layers of 8 bars each (see Fig. 13). The beam impinged on the center of the first upper layer bar and neutron scattering throughout the array was recorded, analyzed, and compared with each of the two simulation predictions [11]. The second experiment (LANSCE 2, November 2019) was focused on better understanding neutron "dark scattering"; which occurs when neutrons scatter elastically from C nuclei and the recoiling carbon produces insufficient light to be detected by the MoNA bars. Dark scattering in the MoNA experiments reduces neutron energy and momentum resolution since the initial scatter goes undetected and the neutron trajectory is altered. For the LANSCE 2 experiment the MoNA bars were reconfigured to include one target bar located near the collimator at the entrance of the 90-m station, and the other 15 detectors arranged in a staircase configuration 1–2 meters away (see Fig. 14). This new configuration was designed to confine the dark-scatter sites from beam neutrons to the center of the single target bar and measuring multiplicity 1 signals in the back detectors to determining the angular distribution.

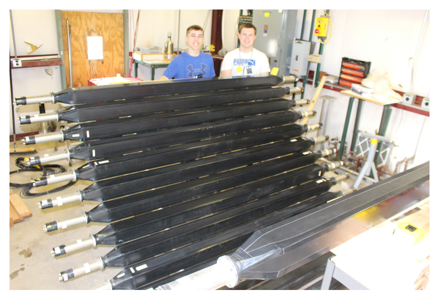

Figure 14: The reconfigured geometry for the second LANSCE experiment, consisting of one target detector (lower right in the picture) located near the collimator, and all other detectors arranged in a sloping ramp 1 to 2 m away, designed to better analyze dark scattering of neutrons.

Analysis of data from LANSCE 2 revealed that approximately 1% of the incoming beam neutrons scatter from the entrance collimator and enter the room over a broad angular range relative to the beam, producing a significant source of multiplicity-1 background events in the staircase detectors. Removal of scattered beam background proved challenging given its significant intensity, approximately 10 times the intensity of dark-scattered neutron events in the back wall, and increases for neutron energies over 100 MeV.

The challenge of removing scattered neutron background from dark scatter observations motivated development of a third experiment (LANSCE 3), which replaces the target MoNA bar with a pair of diamond detectors as active target (see Fig. 15), motivated by recent work done by

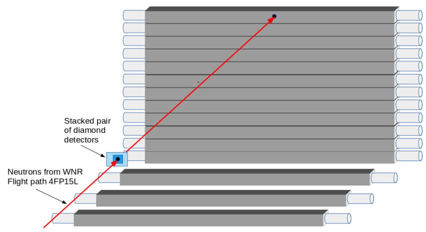

Figure 15: Detector arrangement for LANSCE 3 experiment designed to measure neutron-carbon scattering angular distributions for neutrons up to 400 MeV.

Kuvin et al [Kuv2021]. They measured the response of neutron scattering in a diamond detector at LANSCE for neutron energies to 22 MeV, and were able to detect the elastically scattered C nuclei (which the MoNA bars are unable to detect). Additionally, they were able to resolve signals from separate inelastic n-C scattering channels. Use of a diamond detector for LANSCE 3 will enable observation of both the initial and secondary scatters associated with dark scattering in the MoNA array, as well as to resolve separate inelastic scattering channels in order to better understanding neutron-carbon scattering in MoNA.

The LANSCE 3 proposal was approved, and to date some preliminary data was acquired in late summer 2022, while the full experiment is planned for summer 2023. LANSCE experiments and data analysis is led by the groups at Davidson College and Indiana Wesleyan University.

2.13 MoNA/LISA-Sweeper Relocation

The complete experimental setup of MoNA-LISA and the Sweeper Magnet used to be located in a dedicated vault (N2). The N2 vault has been re-purposed for a different setup, and all MoNA-LISA equipment, including the Sweeper magnet, was removed from N2. Late in 2017 the discussion about the future location of the Sweeper started and included the options of moving to the S3 vault to have a combined Sweeper-S800 setup, or to create a setup in the S2 vault. There was no strong response with experiment proposals that would have relied on a Sweeper-S800 setup, at the same time this setup appeared to be technically challenging to realize. Thus the discussion settled on a new setup in the S2 vault. In order to create an optimized setup in S2, current planning realigns the beam line and has MoNA-LISA placed at the end of the S2 vault to allow for a 6 m to 8 m neutron flight path. A longer charged particle flight path is also possible in the proposed configuration to achieve improved particle time of flight separation, and the Sweeper bending angle will be reduced from 43 degree to 30 degree, thus raising the beam rigidity limit. The reconfiguration

Figure 16: The Modular Neutron Array and Large-area multi-Institutional Scintillator Array (MoNA-LISA).

of the existing S2 vault is planned to take place in 2023 and 2024 to prepare for the approved FRIB PAC1 and PAC2 experiments.

2.14 Technical Overview

Modular Neutron Array

The Modular Neutron Array (MoNA) is a large-area, high efficiency neutron detector designed for neutrons resulting from breakup reactions of fast fragmentation beams.

In its standard configuration, MoNA has an active area of 2.0 m wide by 1.6 m tall (see Figure 16). It measures both the position and time of neutron events with multiple-hit capability. The energy of a neutron is based on a time-of-flight measurement. This information together with the detected position of the neutron is used to construct the momentum vector of the neutrons [11, 12].

The detection efficiency of MoNA is maximized for the high-beam velocities that are available at the NSCL Coupled Cyclotron Facility (CCF). For neutrons ranging from 50 to 250 MeV in energy, it is designed to have an efficiency of up to 70% and expands the possible coincidence experiments with neutrons to measurements which were previously not feasible. The detector is used in combination with the Sweeper magnet [13–17] and its focal plane detectors for charged particles [18]. In addition, the modular nature of MoNA allows it to be transported between experimental vaults and thus to be used in combination with the Sweeper magnet installed at the S800 magnet spectrograph [19]. Due to its high-energy detection efficiency, this detector in conjunction with LISA (see next section) will be well suited for experiments with fast fragmentation beams at FRIB.

Large-area multi-Institution Scintillator Array (LISA)

A collaborative MRI proposal was submitted by nine PUI institutions in the collaboration (CMU, Concordia, Gettysburg, Hope, IUSB, OWU, Rhodes, Wabash, and

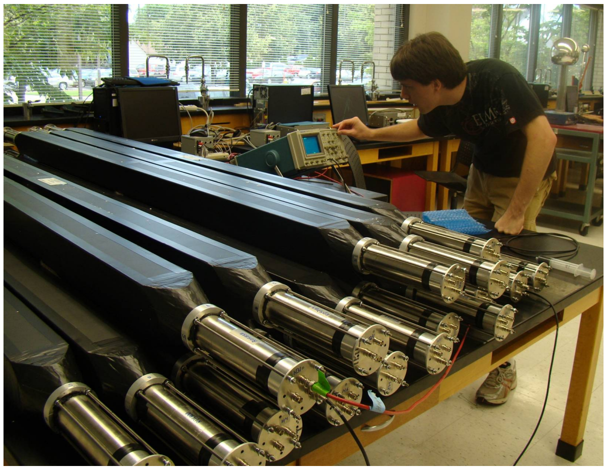

Figure 17: Assembled LISA modules being tested.

Westmont) to enhance the neutron detection capabilities. LISA is a second large array (144 modules, see Figure 17) which can be configured for additional angle coverage or for additional efficiency. The increased neutron detection efficiency possible with the combined MoNA-LISA array means it will be an effective day-one FRIB detector system.

LISA was constructed by undergraduate students at the nine institutions (Figure 17). Construction was essentially completed during the summer of 2010. Each institution carried out testing and used their subset of detector modules for student education. The projects being undertaken by students at each institution range from muon-lifetime measurements, to cosmic-ray shower size measurements, to γ–γ correlation measurements using the full position reconstruction. The modules were moved to NSCL in January of 2011. After mechanical installation was completed, LISA was integrated with MoNA and the Sweeper and the commissioning experiment (neutron unbound states in ^{24}O) took place in June of 2011.

Sweeper Magnet

The Sweeper magnet is a large-gap dipole magnet that was developed and built at the National High Magnetic Field Laboratory at Florida State University [13–17]. It was funded by the NSF with a Major Research Instrumentation (MRI) grant to a MSU/FSU consortium. The superconducting magnet is able to deflect charged particles up to a rigidity of 4 Tm in order to separate neutrons, charged reaction products, and the non-reacting beam particles. The vertical gap between the pole tips measures 14 cm and a large neutron window enables the neutrons coming from the reaction target placed in front of the Sweeper to reach MoNA and LISA, typically placed at 0° with respect to the incoming beam direction.

Segmented Active Target

A segmented target is now available for experiments at NSCL after successful construction and installation at the NSCL in the Spring 2016 (Figs. 19 and 20). The

Figure 18: Sweeper magnet

target consists of alternating layers of Silicon detectors (62 mm x 62 mm x 140 μm) and passive Beryllium targets around 600 mg/cm^2 targets. The energy loss of secondary beam and charged reaction product nuclei are measured in each detector to determine event-by-event in which beryllium target the nuclear reaction occurred. This determination will provide a means to keep the resolution in decay energy measurements constant while using thicker target to increase statistics. In addition, the readout from each corner of the detector provides a position measurement at the target position.

This system was successfully used in an experiment to more precisely measure the lifetime of ^{26}O with-respect-to 2n-emission. Figures 21) and 22 show the position resolution of the system and the capability to separate the reaction products resulting from the incoming beam impinging on each Be-target. The segmented target system is expected to be used in future experiments.

CsI Hodoscope repair

Even while new approaches to measurements of the fragment energy are being developed, an effort to affect a repair of the existing flawed CsI hodoscope has begun. The excellent machine shop facilities at Hope College will be used to lap the existing CsI modules. The hope is that the issue with the detectors is damage to the front few millimeters from residual moisture left at the time of manufacture. CsI is relatively easy to lap and polish

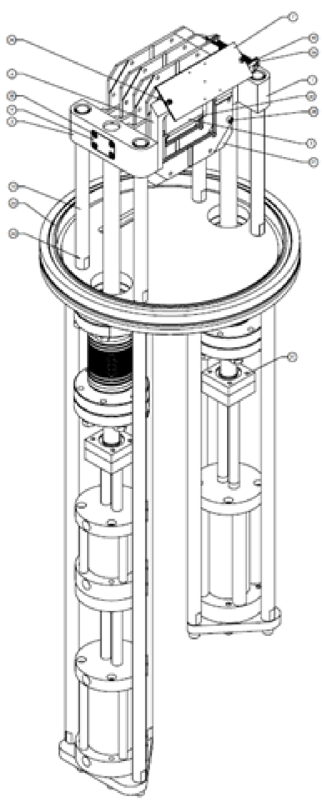

Figure 19: CAD drawing of Si-Be segmented target at the NSCL.

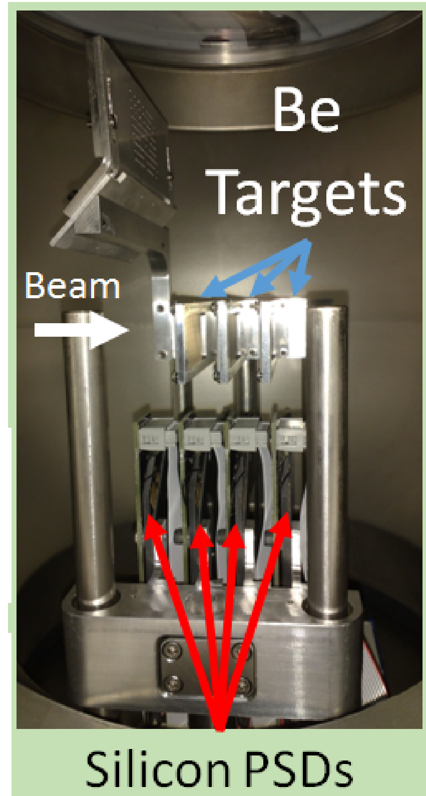

Figure 20: Si-Be target inside scattering chamber. The mask are viewer (upper left) and Si PSDs (bottom) are shown in a retracted position.

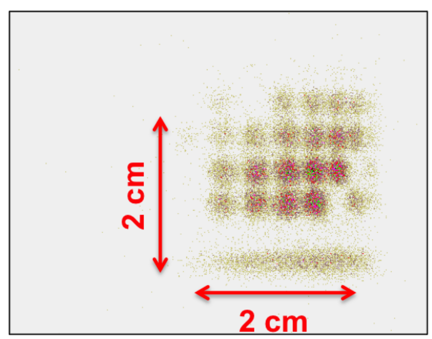

Figure 21: Reconstructed hole pattern from mask runs using the Si-Be target.

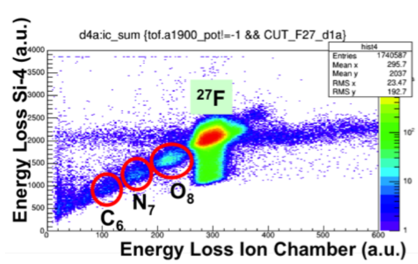

Figure 22: PID with the segmented target: ΔE in the 4^{th} silicon detector vs. ΔE in the ion chamber at the focal plane.

[20, 21] but the process will have to be done to the 15 inch long assemblies rather than individual crystals. The assemblies were glued into monolithic blocks gentle attempts to disassemble were unsuccessful. More radical attempts to break the crystals from their light guides and support structure could cause them to fracture. After lapping a few millimeters from the front, they will be tested with oxygen beams for uniformity with the Hope tandem accelerator. If the repair is successful, the repaired hodoscope could be used while the improved version is implemented. Potentially, the repaired hodoscope could be used with the Sweeper in the S2 location even after the HRS and new hodoscope are in place.

Liquid Hydrogen Target

The Liquid Hydrogen Target at the NSCL offers a high-density, low-background proton or deuteron target for elastic scattering, nucleon transfer reactions, secondary fragmentation, and charge exchange experiments. The target (see 23) works by pumping deuterium gas into a cylindrical chamber sealed with $\sim$100 μm thick kapton foils on either side. The target chamber has a diameter of 5 cm and can provide several target thicknesses depending on the depth of the chamber and density of the gas. Thicknesses of 200 or 400 mg/cm^2 are currently available for deuterium. Liquid helium is then used to cryogenically cool the gas close to the triple point, and a heating block warms the deuterium to approximately 1.5K below the boiling point to keep it in a liquid state. The system can hold 160 L of deuterium at 1 atm. It was used at NSCL for the ^{24}O(d,p) experiment (e12004) whose goal was to measured negative parity states in neutron-unbound ^{25}O.

Experimental layouts

The complete experimental setup of MoNA-LISA and the Sweeper Magnet used to be located in a dedicated vault (N2 vault, see Fig. 24). The N2 vault has now been repurposed for a different setup, and all MoNA-LISA equipment, including the Sweeper magnet, has been moved into storage.

Late in 2017 the discussion about the future location of the Sweeper started and included the options of moving to the S3 vault to have a combined Sweeper-S800 setup, or to create a setup in the S2 vault. There was no strong response with experiment proposals that would have relied on a Sweeper-S800 setup, at the same time this setup appeared to be technically challenging to realize. Thus the discussion settled on a new setup in the S2 vault (see Fig.). In order to create an optimized setup in S2, current planning realigns the beam line and has MoNA-LISA placed on a platform above the S3 vault. This maximizes the neutron flight path. A longer charged particle flight path is also possible in the proposed configuration to achieve improved particle time of flight separation, and the Sweeper bending angle could be reduced from 43 degree to 30 degree, thus raising the beam rigidity limit. These major reconfigurations of the existing S2 vault will happen after the CCF ceases operation and will be available with FRIB beams.

Details of this configuration are being worked out at the time of the writing of this report.

Event-tagged readout

For MoNA-LISA-Sweeper experiments the data from the various detector subsystems are read out in an event-tagged scheme. Each detector subsystem runs its own readout and records its data separately. By using separate data acquisition computers, the system becomes easily expandable, e. g. if an additional detector subsystem like a γ-ray detector needs to be added, while the overall readout time is reduced compared to a system with a large number of VME bins. A common system-wide trigger is generated by the trigger logic. A clock signal is fed into scalers that create an event tag for each time the subsystems are read out. This event tag is used off line to match and re-assemble event data from the subsystems.

2.15 G4MoNA and NPTools

Over the past year, dedicated work was done to improve on existing Geant4 [22] based Monte Carlo simulation packages to provide a new generator for neutron-rich nuclei (MoNA LISA Geant4 Generator, MoLIG), inclusion of Coulomb breakup and multi-neutron emission using the NPTool software [23, 24], and a ST_MoNA like tree in G4MoNA.

NPTool is built on a ROOT and GEANT4 framework. It has a user friendly GUI that makes it very simple to use for basic tasks such as creating a new detector from scratch, finding acceptances, visualizing the setup, and running a simulation with various beams. A plethora of detectors used by the low energy nuclear physics community are available with the installation. An example is shown if Fig. 25. Although the current simulation for the Sweeper setup uses a constant magnetic field, and have no reaction and no neutrons, plans are underway to improve the simulation such as a realistic magnetic field map implementation, the MoNA detector array and neutron physics (lead by Belen Monteagudo), with the latter in collaboration with Adrien Matta, creator of NPTool. Andrew Wantz has also been working on particle identification methods using NPTool simulation, and machine learning methods for improving particle identification with NPTool simulation.

2.16 Machine Learning Applied to Multi-neutron Events and Fragment Identification

Correlations between particles give rise to a range of interesting phenomena. In the case of atomic nuclei, one example involves the spatial localization of two nucleons near the surface of a nucleus resulting from the attractive nuclear force [25, 26], sometimes referred to as dineutron and diproton correlations. In general, nucleon correlations, including the dineutron effect [27–30], are

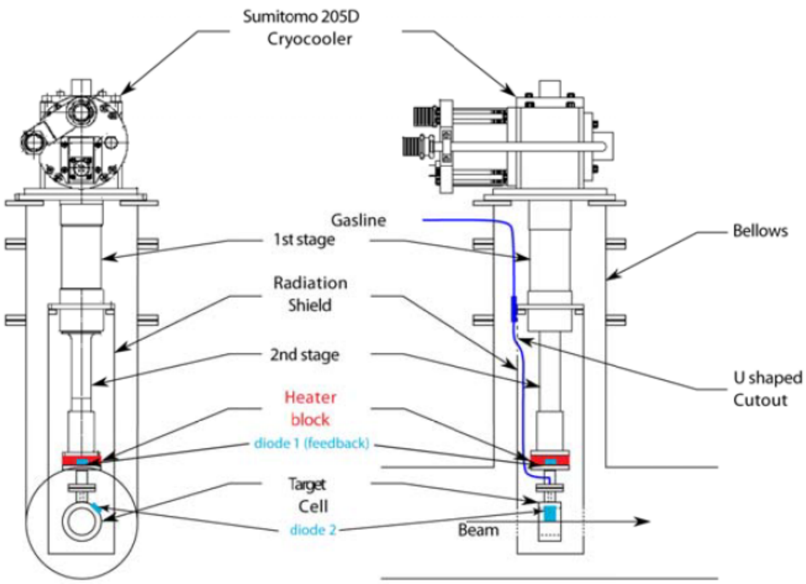

Figure 23: A diagram of the Liquid Deuterium Target illustrating how it will sit in the beam-pipe.

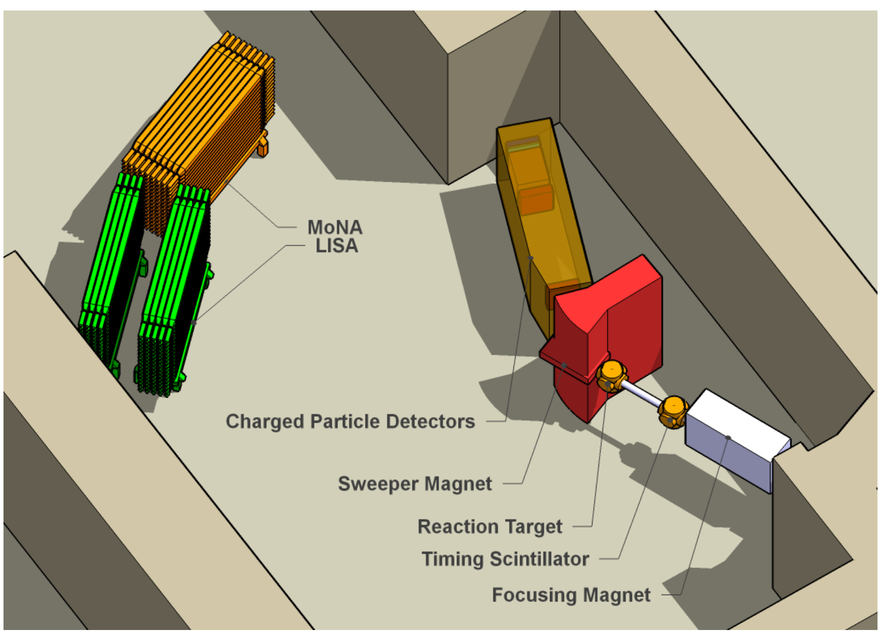

Figure 24: Recent layout of MoNA-LISA in the N2 vault.

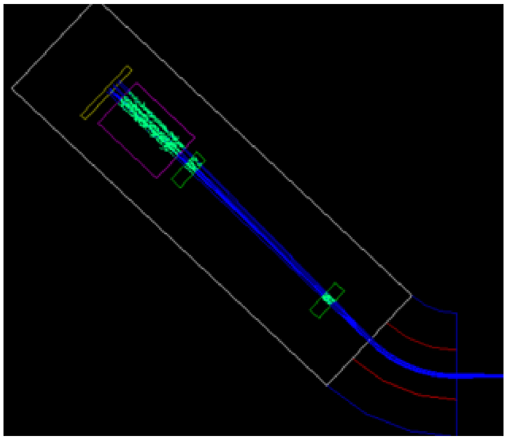

Figure 25: Simulation of the Sweeper and charged detector suite using NPTools.

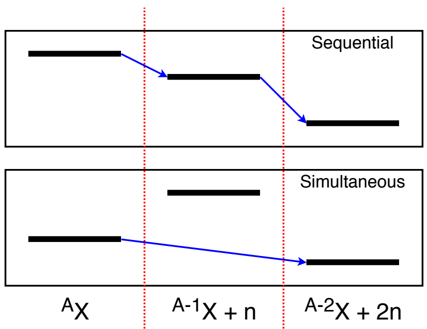

Figure 26: Contrasting energy conditions characteristic of sequential (top panel) and simultaneous (bottom panel) three body decays.

expected to be more easily probed through the study of two-neutron decays due to the absence of the Coulomb interaction present in the case of two-proton decays [31]. One method for probing neutron correlations is to study the two-neutron decays of exotic neutron-unbound systems. In these cases, the goal is to observe three body decays (fragment plus two neutrons) of systems that simultaneously emit two neutrons as opposed to a sequential decay through an intermediate state (see Figure 26). Two-neutron emission has been observed from ^{5}H, [32–35], ^{10}He (see Chapter 2 of Ref. [9] for a summary of the ^{10}He measurements), ^{13}Li [36, 37], ^{16}Be [38], and ^{26}O [39–42], and studies of neutron correlations have been made for several systems [32, 35, 43, 44, 38, 45, 36, 46]. The specific case of the ^{26}O ground state has been the subject of theoretical [47, 31, 48, 49], and experimental studies, however, an experimental determination of the nature of the neutron correlations for this case remains ambiguous due to the near-threshold ground state resonance and to statistical limitations [46]. This indicates a need for innovative experimental techniques to study certain systems.

Accumulating sufficient statistics will always be a challenge for experiments that study nuclei along the neutron dripline. The intensities of the rare isotope beams used to populate the neutron unbound systems can range from ∼10 to ∼1000 particles per second [50, 51]. The new beam production capabilities of FRIB will enable heavier exotic nuclei to be studied, and these restrictions will apply to eventual studies of neutron-unbound systems. Furthermore, the cross-sections for the types of reactions used to produce the unbound systems are small, ∼1 to ∼0.1 mb [52]. Apart from increasing the reaction yield, improvements to the event selection procedures for analyzing two-neutron decay data can reduce the number of good events that are rejected in the course of the analysis. This avenue is also being investigated by the MoNA Collaboration and a new analysis procedure for identifying two-neutron events is showing promising results. It should be noted that these analysis techniques can be useful for studies of sequential two-neutron decays as well as three- and four-neutron decays (e.g. [53, 54]), not just the simultaneous two-neutron emission mentioned above.

As an extension to this technique, we plan to investigate the possible uses for machine learning techniques in analyzing measurements made by large scintillator arrays in order to improve the identification of events in which two neutrons resulting from the decay of a neutron-unbound system are detected. This project will expand the research activities of the nascent nuclear science research group at Virginia State University (VSU) while offering engaging research opportunities for VSU undergraduate students.

Preliminary results from the first iteration of a neural network (NN) classifier are shown in FigureThis approach trained a single layer network to distinguish between signal and background events for a subset of simulated data containing only events in which exactly two hits were registered in MoNA-LISA. Signal events are those in which two separate neutrons are detected, and background events are those in which the two hits result from a single neutron interacting twice. When applied to data from the Collaboration's 2016 measurement of ^{26}O [42, 55] the classifier outperforms simple cuts on hit separation and velocity difference in terms of statistics preserved in the three-body relative energy spectrum (see Figure 27). Evaluation of the two methods The VSU group is working to develop a labeled event library that can be used to validate machine learning methods trained on simulated events.

To improve particle identification, machine learning methods have been developed using TMVA, the Toolkit for Multivariate Analysis, which is integrated within ROOT. Classification and regression algorithms have been trained and tested on NPTool simulation. Various methods have been compared, including the Deep Neural Network, Multi-layer Perceptron, and Boosted Decision Tree. Initial returns are very promising but require further testing. One of the main goals is to train the machine learning methods on NPTool simulation then test

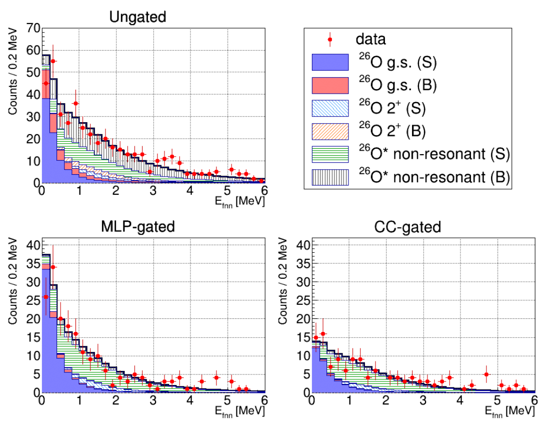

Figure 27: A single-layer neural network classifier is compared to simple cuts on hit distance and velocity separation for selecting two-neutron signal (see text) events from measured and simulated datasets for the ^{26}O two-neutron decay. The upper left panel shows the three-body relative energy spectrum with no gates applied to suppress the one-neutron scattering background. The red filled circles with error bars show the measured data, the histogram outlined by the thick black line shows the sum of three simulated ^{26}O decay channels, and the contributions to the sum are indicated by the colored shading. The blue (red) solid shading represents the signal (background) contribution from the ^{26}O ground state resonance, the blue (orange) diagonal shading represents the signal (background) contribution from the decay of the ^{26}O 2^+ excited state, and the green (black) horizontal (vertical) shading denotes contributions to signal (background) from nonresonant two-neutron emission. The lower left panel shows the three-body relative energy spectrum after the classifier is applied. The lower right panel shows the result of applying two cuts, one requiring the hit separation to be greater than 25 cm and the second requiring the relative speed between the hits to be greater than the speed of the first hit.

them on experimental data, specifically Dayah Chrisman's Neon isotope identification plot (e16027). However, to do this, the relatively simple NPTool simulation needs to be improved, which is currently in progress. Another goal is to use the events in which we are most confident in the experimental PID plot as the training data, then use the rest of the events as the testing data, thereby determining whether we can use solely experimental data to improve the PID via machine learning.

2.17 Auxiliary Uses of MoNA-LISA

In addition to the primary fragmentation physics, there are some off-line uses for MoNA. These include measurements of the temporal and spatial dependence of the cosmic-ray flux. These efforts provide additional student training with acquisition, detectors, and analysis.

3 The MoNA Collaboration

3.1 History

When the NSCL upgraded their capabilities to the Coupled Cyclotron Facility, an FSU/MSU consortium built the Sweeper magnet to be used with two existing neutron walls to perform neutron–fragment coincidence experiments. The neutron walls were originally built for lower beam energies and had only a neutron detection efficiency of about 12% for the energies expected from the CCF. During the 2000 NSCL users meeting a working group realized the opportunity to significantly enhance the efficiency with an array of more layers using plastic scintillator detectors.

Several NSCL users from undergraduate schools were present at the working group meeting and they suggested that the modular nature and simple construction would offer great opportunities to involve undergraduate students.

In the spring of 2001 the idea evolved into several MRI proposals submitted by 10 different institutions, most of them undergraduate schools. The proposals were funded by the NSF in the summer of 2001. Following the detailed design, the first modules of the detector array were delivered in the summer of 2002. During the following year all modules were assembled and tested by undergraduate students at their schools [57], and finally added to form the complete array at the NSCL (Figure 28).

The MoNA collaboration continued after the initial phase of construction and commissioning was concluded [58], and is now using the detector array for experiments, giving a large number of undergraduate students from all collaborating schools the opportunity to take part in cutting-edge nuclear physics experiments at one of the world's leading rare-isotope facilities. The research at the undergraduate institutions is funded by the NSF through several RUI grants (Research at Undergraduate Institutions). Since the completion of the original set of MoNA

Issues and Events

Undergraduates Assemble Neutron Detector

Spreading the construction of a detector across several institutions brings project visibility to participants.

"The undergraduates come running." So says Ruth Howes about student participation in the Modular Neutron Array, or MoNA, a detector built in large part by undergraduate physics majors. Howes, chair of the physics department at Marquette University in Milwaukee, Wisconsin, says it is unusual and significant that students can work on MoNA without leaving their home institutions. The detector was installed last summer at the National Superconducting Cyclotron Laboratory (NSCL) at Michigan State University in East Lansing.

With MoNA, says MSU's Michael Thoennessen, the project's leader, "we can address one of the most interesting questions in heavy ion physics: For a given proton number, what's the heaviest isotope you can make?" For oxygen, this limit—called the dripline for isotopes that persist for milliseconds—is ^{24}O; with one more neutron, ^{25}O lives only 10^{-21} seconds. An experiment planned for MoNA, Thoennessen adds, "is to take a beam of fluorine-26, which we can make here at the lab, and send it to a thin target, typically beryllium, to strip a proton. Then ^{26}F becomes ^{25}O, which decays immediately into ^{24}O." From the ejected neutron's time-of-flight and position on the detector, "we can get the neutron's energy and can reconstruct to show that ^{25}O was created, how long it lived, and what its decay energy was," says Thoennessen.

The facilities offering the biggest competition for MoNA, he adds, are GSI in Darmstadt, Germany, RIKEN in Tokyo, and GANIL in France.

Ranking right up with the project's scientific potential is student involvement, which helped drum up funding. Recalls Jim Brown, a physicist at Wabash College in Crawfordsville, Indiana, "At a users' meeting, I popped off with, 'Nothing looks too difficult to assemble. We could get undergraduates.' My idea was that it would involve my students—it would give my guys something to do that would be good. Michael Thoennessen called a couple of months later, and said yes." NSF funded the project with more than $900 000, split among the 10 campuses that built MoNA.

Nontraditional students

The detector consists of 144 two-meter-long plastic scintillator bars arranged in 9 vertical layers of 16. Photons created when incident neutrons interact with the scintillator are recorded by photomultipliers at the ends of the bars. MoNA is sensitive to neutron energies from 50 to 250 MeV.

Perhaps the most novel aspect of the construction process was that students could work on MoNA from their home institutions. To be sure, some did go to NSCL through NSF's Research Experience for Undergraduates program. But others signed on directly through their physics departments. "Increasingly, undergraduate physics departments are seeing nontraditional students," says Howes. "One of my undergraduates had been a funeral director. He was 30 and had a steady girlfriend. Another had worked in industry and had a wife. They appreciate being involved in real, publishable research, but they can't leave home the way 20-year-olds can, for the whole summer."

A local presence on college campuses brings other benefits, Howes says. "Pieces of hardware were delivered to undergraduate institutions. That meant we had labs with equipment. This is far more interesting to a casual passerby than a work station." As a result, she adds, it is easier to attract students and to obtain the internal grants and fellowships that "you depend on when you are at a small college." MoNA members, in addition to MSU, Marquette, and Wabash, are Central Michigan University in Mt. Pleasant; Concordia College in Moorhead, Minnesota; Florida State University in Tallahassee; Hope College in Holland, Michigan; Indiana University at South Bend; Western Michigan University in Kalamazoo; and Westmont College in Santa Barbara, California.

Phil Voss, who began working on MoNA as a junior at Central Michigan University, describes a stint at MSU: "We had two hours of lectures every morning. We calibrated [the detector], did some dirty work, painted a couple

The Modular Neutron Array (left) was assembled by undergraduates (above) at Concordia College and nine other institutions.

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March 2005 Physics Today 25

Figure 28: Physics Today article about MoNA [56]

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Figure 29: Undergraduate students are being trained in the assembly and testing of MoNA detector modules.

detectors, there have been several changes to the membership of the Collaboration. Must recently, the Collaboration welcomed Anthony Kuchera (Davidson College) and said goodbye to Joe Finck (retiring from CMU).

3.2 The Role of Undergraduate Students

The physical characteristics and performance of MoNA were not the only things carefully considered by the collaboration. From the outset, several goals for the education of undergraduate students were identified: How can these students be continually and effectively involved in forefront research? What are the benefits to the students from this participation? What are the benefits to institutions and faculty members? When students participate in the experiments and when they work with the data sets, how can they evolve from passive watchers to active doers with the responsibility to get answers?

The collaboration has addressed this challenge by creating intensive summer sessions designed for undergraduates, encouraging students to participate in all phases of experiments, holding several meetings a year that include undergraduate participants, and employing information technology to bring the distant undergraduate students together (Figure 29).

Many voices have recognized the need for a strong basic science program in the United States. Most recently the National Academy of Sciences published the "Rising Above the Gathering Storm" study that outlines consequences and needed actions. The coming decade will need a steady stream of people (new physicists) as well as strong financial support. As in the past many of these people will come from undergraduate institutions and the most prepared will be those involved in meaningful undergraduate research as done by the MoNA collaboration at the NSCL involving fragmentation. While planning future installations for nuclear physics, the value of this educational approach and training must be recognized. Undergraduates must be involved in an affirming environment where they are engaged at a high intellectual level and truly challenged so they are ready for the work yet to be done. The MoNA Collaboration has now established itself as a powerful collaboration with a strong track record in training undergraduate students to do research and produce peer reviewed articles in nuclear physics.

Outcomes

Since the start of this collaboration, more than 100 undergraduate students from over 25 different colleges and universities as well as a few high school students have been actively involved in building, testing, and operating the MoNA and LISA detectors (see Section 8).

These diverse undergraduate students have worked with one another in assembling and testing MoNA and LISA and in operating it during experiments. They have pulled shifts and put in the long hours that are characteristic of work in experimental nuclear physics. The graduate students and post docs at the NSCL provide approachable role models for them, and they feel free to ask questions of any of the faculty members in the group. For students from small undergraduate physics departments, participation in the MoNA collaboration provides a chance to experience the way physics is done in a large graduate physics department and at a world-class nuclear physics laboratory. The experience is particularly important for students who do not go on to graduate school in physics because they gain an understanding of how hard experimental scientists work to uncover the data points that underpin the theories written up in science texts and news magazines. The support of physics students who do not work as nuclear physicists but have careers in industry, K-12 education, or even the arts is important in reaching the non-scientists who control the funding for nuclear physics.

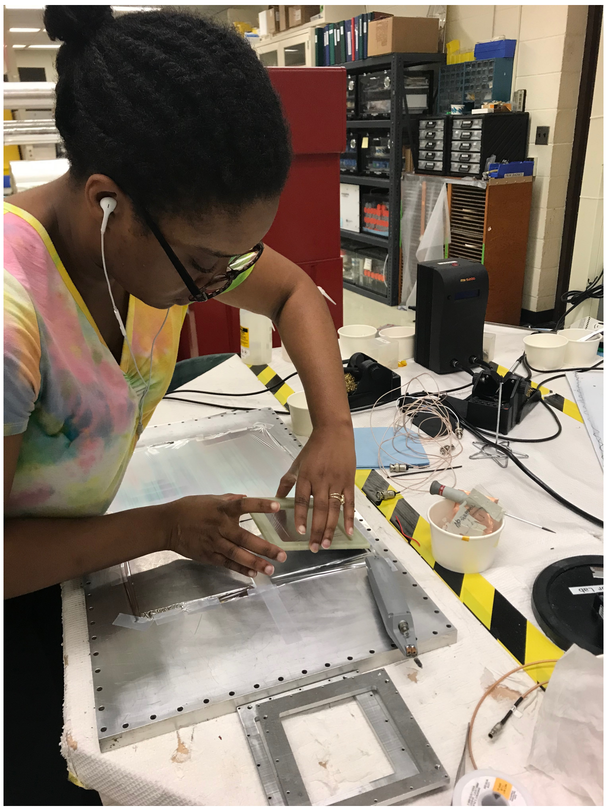

Figure 30: Undergraduate April Christopher working on a prototype GEM detector for next generation MoNA detectors.

Distributed analysis

A feature of the MoNA collaboration that is an outgrowth of our collective work with undergraduate researchers is the emphasis on doing more than detector assembly or running shifts. In particular, the collaboration has a mechanism in place that allows the undergraduates to carry out the actual data analysis of the experiments.

One mode is that a student, with guidance from their mentor and the collaboration, has the primary responsibility for the analysis much like a traditional graduate student; other students may be involved but that student does much of the work and oversees and integrates the work of others. Students can work with more senior researchers where they provide hours on task and have a good overview of the experiment but do not have the ultimate responsibility for the results. Undergraduate students with limited time for work can still participate by working on very focused aspects such as the calibration of a single detector subsystem, code checking, or validation of the work of others (Figure 30).

Lastly, some collaboration members have undertaken the difficult task of improving the analysis algorithms and extending the detailed understanding of operations. MoNA undergraduate students at Westmont College have developed an algorithm to distinguish neutron multiplicity based on the kinematic propagation properties of neutrons though MoNA. Initial analysis of several one- and two-neutron experiments show promise. Scatter plots of neutron velocity and energy deposition versus scattering angle reveal a locus of points in which single-neutron events lie. Multiple-neutron events show as relatively uniform scatter throughout the plots, as there is no correlation between each individual neutron interaction in those instances besides the kinematics of the breakup which produced them.

Every student who wanted to work on analysis has been able to do so. Undergraduate work has contributed to a number of publications and presentations (see Section 7).

We are able to involve undergraduate students in this way because we have the tradition of expecting such work

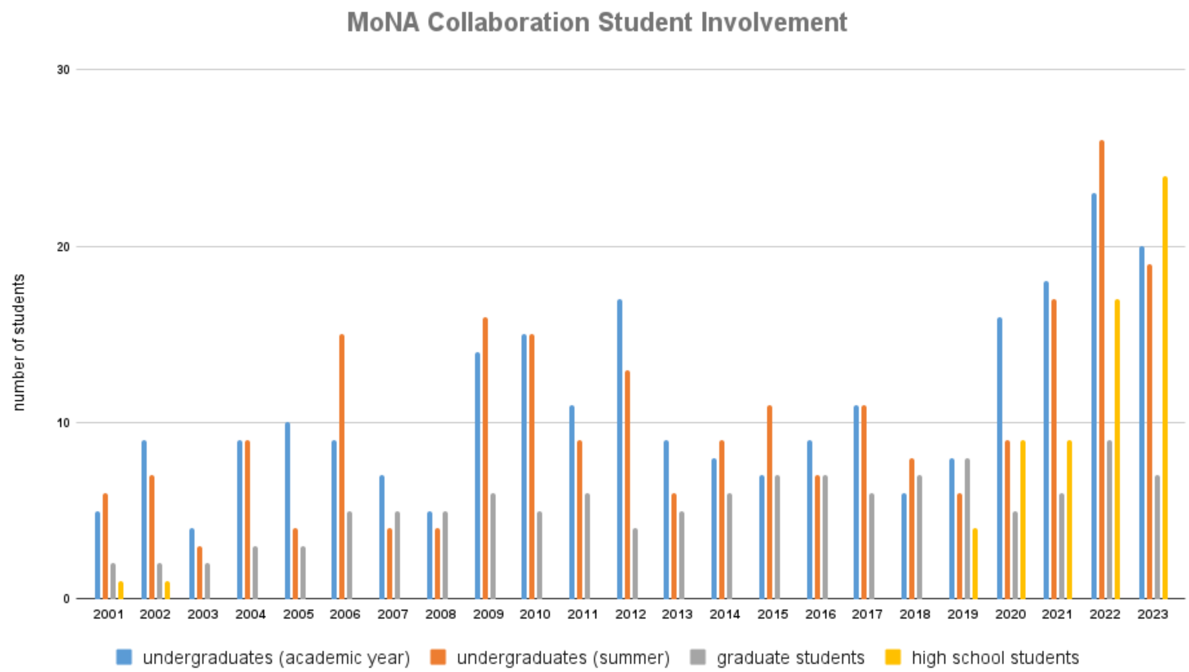

Figure 31: MoNA Collaboration student involvement over the years.

from our students but also because of the close working relationship between the members of the collaboration. Frankly, it would be difficult for single researchers from a primarily undergraduate institution to work successfully with their students on the analysis of such measurements in isolation. The fact that both students and faculty involved in the research participate in regular videoconferences where recent results and problems can be discussed with others also working on the same experiment or related analyses is crucial. This shared expertise strengthens the group effort and provides undergraduates and their faculty mentors with needed support in the analysis of the data.

Giving the students responsibility for the analysis in these ways additionally results in increased effectiveness during the actual experiments. They are much more involved and make significant contributions by doing preliminary analysis as the data is being recorded.

But the largest benefit to this type of undergraduate involvement is that they are enthused to continue on to graduate study and they are extremely well prepared to continue in research. They have mastered many fundamental research skills and understand the problem solving process that is essential to carry research through to a conclusion. In fact, the MoNA collaboration has dramatically impacted the interest of undergraduate students in pursuing physics graduate school with an emphasis in nuclear physics (Figures 32 and 33).

The MoNA collaboration has had a significant impact regarding the increase of the STEM workforce. The current

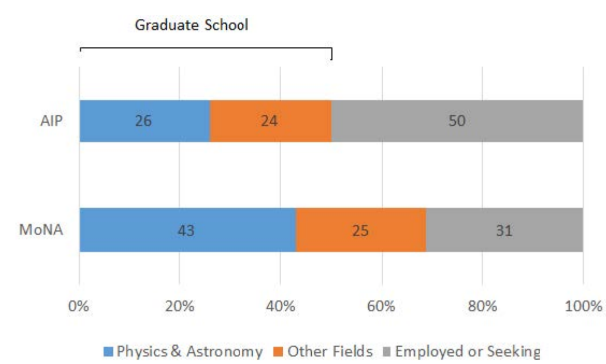

Figure 32: Career choices of BS/BA graduates from bachelor's granting institutions in the U.S. from an AIP survey [59] and from the MoNA collaboration. The AIP data is from 1974 respondents from 2011 and 2012, and the MoNA data is based on 97 students from 2002 to 2014.

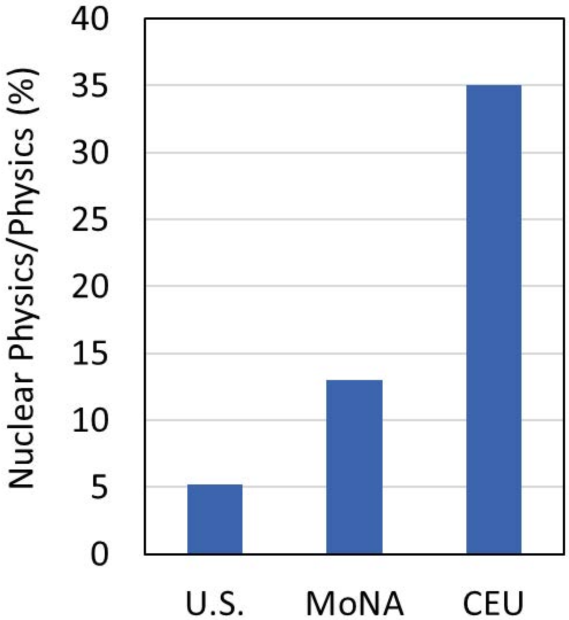

Figure 33: Fraction of graduate students in Nuclear Physics. The U.S. fraction corresponds to the average number of PhDs from 2000–2012 [60].

job distribution of students is shown in Fig. 34: about 75% of the students go into graduate school or are pursuing a STEM career.

Summer research

Summer is still the best time for undergraduates to get involved in major research projects. In addition to the undergraduate students from the collaborating institutions, many REU students joined the research efforts during the summers. The collaboration used this opportunity for workshops to teach the students about all aspects of MoNA. These workshops include formal presentations and mini-lectures on the experimental details and pertinent background material such as radioactive beam production, laboratory safety, and experimental electronics. These duties are shared amongst the collaboration's undergraduate professors and NSCL staff. The talks last an hour and a half each morning and then the students are put to work—finishing preparations, calibrating, and testing components—throughout the afternoon and into the evening. This intense and rigorous training period typically lasts for two weeks and culminates with an experiment that employs a lot of what the students just learned. At the end of the three week session, the students return to their summer obligations or begin analyzing the data from the experiment. Several of these students, well prepared by the MoNA Summer Session, return during the school year to help with other experiments.

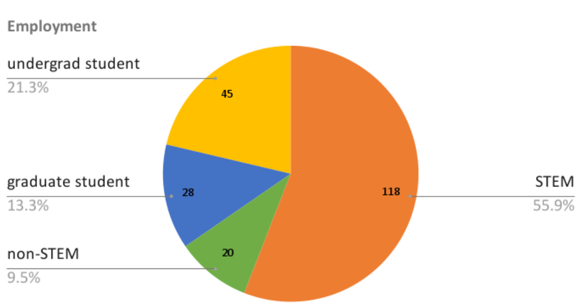

Figure 34: Job distribution of MoNA students (80.5% reported). 43 students are still in college, 26 students are currently in graduate school, 116 are employed in STEM fields, 20 are in non-STEM fields.

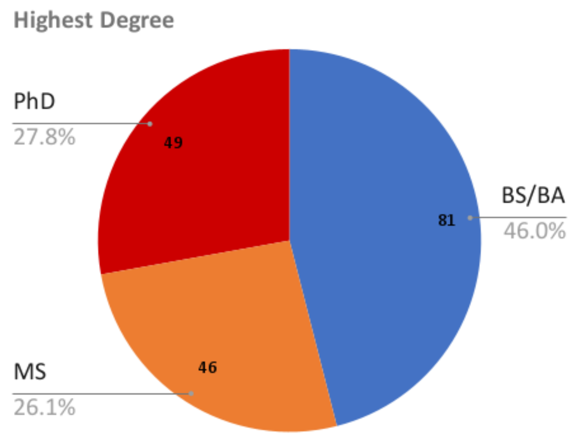

Figure 35: Highest earned degree of former MoNA students (67.2% with degree/reported).

Collaboration retreat

Near the end of each summer the MoNA Collaboration has historically held a retreat at the Central Michigan Biological Station on Beaver Island, located in the norther tip of Lake Michigan (from 2004 to 2013). In 2014, the retreat was held at Michigan State University, in 2015 the retreat was held at Westmont College in Santa Barbara, CA, and in 2016 the meeting was hosted at Wabash College, IN, and the 2017 meeting was held at the MSU Kellogg Biological Station in Hickory Corners, MI. Since 2018 themeetings were held at the NSCL or FRIB. Faculty and students participate in this annual gathering to write papers, discuss analysis, develop proposals for experiments and external support, and plan for the year ahead (Figure 36).

At the 2005 Beaver Island retreat a proposal was developed and subsequently received funding of $50,000 from the Research Excellence Fund of Michigan to purchase digital video-conferencing equipment. In addition to the specific needs of the MoNA collaboration that this hardware is intended to address, the video-conferencing infrastructure has offered substantial benefits to individual student and faculty participants at the member undergraduate institutions, to these institutions themselves, to the collaboration, and to the broader profession.

Figure 36: Participants of the 2023 Collaboration Meeting which was held mostly in-person.

The equipment has allowed undergraduate students to participate in the real-time acquisition and off-line analysis of data. This novel remote approach to doing physics will give students the opportunity to participate in MoNA experiments together with other collaborators from multiple off-site locations and from the NSCL. Students are no longer prevented from participating in an experiment due to academic-year course commitments or travel constraints. The digital video conferencing system also allows faculty and students to have regular group, subgroup and point-to-point meetings where pre-experiment planning is being discussed and post-experimental data analysis is coordinated. The system is further being used for training, educating and motivating students who are new to the project. The system compliments the other forms of communication used by the collaboration, such as databases, websites, phones, and e-mail.

Data analysis and real-time experimental participation, facilitated by the conferencing system, will help students to foster stronger and more confident ties to the MoNA collaboration. This aspect of regular collaborative face-to-face interaction with members of the MoNA collaboration will continue to allow students to be genuine members of the group and contribute to the physics results produced by the collaboration.

Why undergraduate participation works so well with MoNA at NSCL

The MoNA collaboration has found it very easy to involve students in the fragmentation studies at NSCL. The students can readily grasp the basic goals of the measurements. As stated above, the academic atmosphere works well for the faculty and the undergraduate students fit in well (they especially relate to the graduate students), but additionally, the physics is easy for the students to understand. The reconstruction of the original nuclear mass is based on relativistic four-vectors. The nuclear shell model and single particle states, while complex in detail, can easily be related to atomic shells. The students are able to see the big picture while being involved in the experimental detail. Students see moderately complex detector systems but which are actually easily understood. (The concept of determining neutron energy from time-of-flight can be understood by first-year students.) The physics based on fragmentation provides tremendous opportunities for the undergraduate researcher (and their mentors).

In no small measure, the MoNA collaboration has been able to successfully and meaningfully involve undergraduates because the NSCL is an academic setting. The significant interaction of the undergraduate students with the graduate students and senior researchers, that are also instructors, has been very beneficial. The undergraduates are always greatly affirmed and encouraged. The mentors of these students also appreciate the support received from fellow academics.

MoNA Collaboration statement on membership

The MoNA Collaboration is committed to performing research at the forefront of nuclear science with significant involvement of undergraduate students. It was founded by multiple PIs who were awarded NSF grants to construct the original 144 MoNA bars. A second round of proposals was awarded to another group of PIs to build the next 144 bars, known as LISA. Other members have become PIs by a significant contribution in the form of equipment development or expertise in an area of value to the collaboration. Examples include a CsI hodoscope, Si-Be segmented target, simulation development, and digital data acquisition testing. We aim to be an inclusive collaboration and welcome new members with the understanding that new members will work with the existing members to determine how they too can best bring new value to the collaboration.

3.3 Physicists Inspiring the Next Generation

Physicists Inspiring the Next Generation (PING) is a program for pre-college students and undergraduate students. The program was started by Paul Guèye in 2014 as a collaboration between the National Society of Black Physicists (NSBP) and the National Radio Astronomy Observatory (NRAO) in partnership with Associated Universities, Inc. Since then it developed into a two-week summer research "Exploring the Nuclear Matter at the Facility for Rare Isotope Beams" which was piloted in 2019. This program is now fully funded by the NSF (NSF award PHY-2012040 since fall 2020), but was held on-line in 2020 and 2021 due to COVID (see Fig. 37).

The purpose of the program is to inspire high school students to work in research fields, nuclear physics in particular, and at the same time to offer undergraduates an opportunity in mentoring. Each undergraduate student is paired with a high school student, and they work on a specific simple research project that can show some results within the two weeks of the summer research (see e.g. Fig. 38). The students are also offered to continue this research throughout the fall semester if they

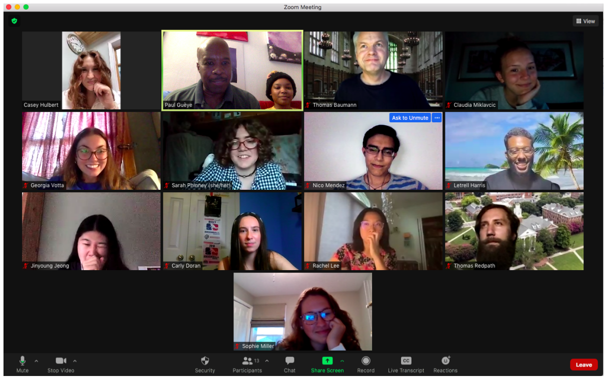

Figure 37: Participants of PING2021 summer research during a Zoom session.

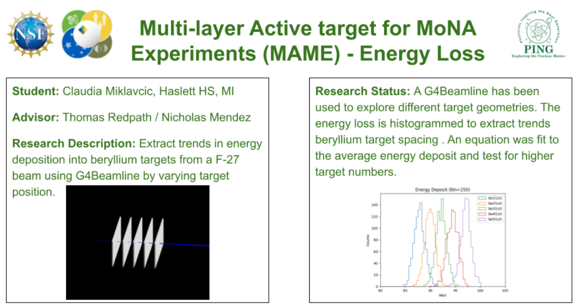

Figure 38: PING research example investigating the energy loss in an active target design.

are interested (and many are). Participants present their work annually at the National Society of Black Physicists (NSBP) meeting and the American Physical Society Division of Nuclear Physics (DNP) fall meeting.

While the program is not limited to MoNA physics, many projects are associated with MoNA research topics.

4 Broader Impact

4.1 PING

The *"Physicists Inspiring the Next Generation (PING): Exploring the Nuclear Matter"* consists a two-week summer program and a year-long academic program to expose pre-college (e.g., middle and high school) students to college level research relevant to rare isotope science, college experience and career pathways [61]. The program also includes an art component and an application to society that bridges to rural (agricultural) communities. It is conducted at FRIB in collaboration with the MoNA Collaboration.

Undergraduate students conduct a summer research internship at FRIB during which two-week are dedicated to mentoring the pre-college students. This program was piloted in the Summer 2019 at Michigan State University with 4 high school students and two undergraduate students. In the Summer 2023, this program has now grown to 24 high school students and 9 undergraduate students. Figure 39 shows the students along with their parents and mentors, including PING2022 students. The

Figure 39: PING2023 students.

research component also evolved from building parallel plate avalanche chambers intended to the Rutherford scattering experiment during which students measured the angular distribution of alpha particles scattering off gold and aluminum foils Figs. 40).

Figure 40: PING2023 students working on Research.

A detector based on this elastic scattering process is funded by the "Windows on the Universe: Study of Open Quantum Systems at FRIB" to provide a normalization between MoNA experiments. The summer project for the PING students serves as a benchmark for this detector which will also allow to extract nuclear radii of rare isotopes. Students will give presentations about their research during the annual meetings of the American Physical Society Division of Nuclear Physics and National Society of Black Physicists in the Fall 2023 semester and at the American Physical Society April meeting in the Spring 2024 semester.

4.2 Workforce Development

The MoNA Collaboration has historically engaged undergraduate students in its research with the majority pursuing graduate studies in nuclear science and the remaining in other STEM field. A smaller faction enters directly the workforce.

The MoNA Collaboration added two new institutions (Davidson College and JMU) and increased the diversity of its membership. We engaged to foster student participation from minority serving institutions in experiments, data analysis, and detector development at the then NSCL and now FRIB, including participation to minority conferences. New outreach to tribal colleges started with involvement from Navajo Technical University, New Mexico, and another in progress from Saginaw Chippewa Tribal College, Michigan. Outreach to impact on the next generation workforce resulted in an increase by a factor of three or better across various groups: overall MoNA undergraduate students population (from 16 to 48), underrepresented groups (from 6% to 18% within MSU Physics & Astronomy Department), and pre-college (from 4 to 24).

Figure 41: PING2023 students with MSU Interim President (Teresa Woodruff), FRIB lab Director (Thomas Glasmacher), representatives from the French National Center for Scientific Research.

4.3 World-wide Impacts

5 Conclusion

A great deal of cutting edge physics remains to be done utilizing fast fragmentation beams. The evolution of shell closures (magic numbers) as the stabilizing influence of protons in the same orbitals is lost for the most neutron-rich nuclei, which continues to be of particular interest. An additional focus is the study of neutron pairing correlations, which can be studied using neutron-rich nuclei in which sequential two-neutron decay is energetically forbidden, and only direct two-neutron decay can occur. Moreover, reaction studies and cross-section measurements can reveal, e.g., neutron and radiative strength functions. Reactions on exotic nuclei involving neutrons are also often of importance for explosive scenarios in astrophysics.

Many of these neutron-rich nuclei will be accessible at sufficient intensities and at nearly optimal beam velocities as fragmentation beams at a facility like FRIB.

The MoNA collaboration has been able to take advantage of the varying areas of expertise of its members to create a collaboration which has effectively involved undergraduate students from its beginning and continues to do so to this day. Students readily understand the nature of these experiments, and can participate in meaningful ways. The impact on these students of exposure to the international-level research currently conducted at NSCL is significant, and helps to train the next generation of physicists. A future isotope research facility that could continue this excellent support of undergraduate research would be welcomed by the MoNA collaboration, and would be an asset for our field of research.

6 Previous Director's Statements

The MoNA Collaboration consists of a group of researchers, most from primarily undergraduate institutions, who are pursuing studies of nuclei close to and beyond the neutron dripline using the Modular Neutron Array (MoNA). These experiments can only be done with neutron-rich nuclei produced via projectile fragmentation, as carried out, for example, at the National Superconducting Cyclotron Laboratory (NSCL) at Michigan State University, where MoNA is currently located.

Since the first detectors of MoNA arrived for assembly in 2002, 64 undergraduate and high school students (as of Spring 2007) have participated in cutting-edge research in nuclear physics as part of the MoNA Collaboration. These students have assembled and tested the components of MoNA, participated in MoNA experiments and workshops at the NSCL and in the annual collaboration retreat, and played a central role in data analysis.

The MoNA collaboration has been a model for involvement of undergraduates in forefront research. The collaboration is committed to continuing its role in the study of nuclei at the limits of stability and in the training of the next generation of nuclear scientists. Our experience over the last six years leads us to the following observations:

- Studies of nuclei at the neutron dripline utilizing beams produced by fast fragmentation produce cutting-edge science. These experiments are well suited to meaningful participation by undergraduate students in a multi-institution collaboration.
- The collaboration has thrived in a university setting, where undergraduate education is at the core of the institutional mission.

We look forward to a next generation facility for rare-isotope beams which would ensure the continuation of this successful scientific and educational collaboration for years to come.

Jerry Hinnefeld
Executive Director, the MoNA collaboration
South Bend, January 17, 2007

Since the last version of this document the MoNA Collaboration has continued to thrive and grow. More than 100 undergraduate students have now been part of the collaboration's scientific endeavors playing vital roles in the study of the nuclei at the limits of stability. Our collaboration has grown in other ways as well. New institutions and investigators have joined the collaboration. Sharon L. Stephenson (Gettysburg College), Nathan Frank (Augustana College in Rock Island, IL), Artemis Spyrou (Michigan State University), Robert A. Kaye (Ohio Wesleyan University) and Deseree Meyer Brittingham (Rhodes College) are bringing new skills and insights to the collaboration's work. In addition a new detector system is under construction by undergraduates at the collaboration schools. LISA, the Large multi-Institution Scintillator Array, will work in conjunction with MoNA to increase our ability to measure angular distributions of reaction neutrons as well as improve the resolution and efficiency of detection in our experiments.

The MoNA Collaboration has always been forward-looking whether in the preparation of the next generation of physicists or in the construction of detectors that are ready for use in the next generation of rare isotope beam facilities (FRIB). Today, we see a bright future for the collaboration, the NSCL, and rare-isotope physics.

Bryan A. Luther
Executive Director of the MoNA Collaboration
Moorhead, MN, Sept. 9, 2010

In the last two years, the MoNA Collaboration has completed LISA, the Large multi-Institutional Scintillator Array. Twenty-three undergraduates worked on construction, testing, and installation of LISA, with additional students playing key roles in data analysis. A successful commissioning experiment in June 2011 continues our scientific program of probing nuclei at the limits of stability. The higher efficiency and better resolution of MoNA LISA combined will allow the collaboration to study a wide array of isotopes that will be available when the Facility for Rare Ion Beams (FRIB) comes online. Extensive, meaningful undergraduate involvement in the cutting-edge science provides pivotal research experiences for students and contributes to training the next generation of nuclear scientists. The collaboration continues to exemplify a successful partnership between primarily undergraduate institutions and a large research university. We are excited about future research and educational opportunities that will be possible with FRIB and as our collaboration continues to grow.

Deseree Meyer Brittingham
Executive Director, the MoNA Collaboration
Beaver Island, MI, August 20, 2011

The MoNA Collaboration has continued to demonstrate growth in its scientific and educational objectives and outcomes since the production of the last White Paper. Since the beginning of 2012, 15 papers in refereed journals were published collectively by the collaboration, including cutting-edge studies of the ground-state dineutron decay of 16Be and two-neutron radioactivity in the decay of ^{26}O. A hodoscope particle detector array, intended to increase the sensitivity of the identification of charged fragments, was developed by Augustana College and was implemented in a commissioning experiment at the NSCL last summer. Paul Gueye (Hampton University) has joined the collaboration and is involved in an effort to develop a segmented target, which will determine the location of nuclear reactions within the reaction target and thus provide better resolution in decay energy measurements. Additionally, our mission to help educate the next generation of scientists remains an important cornerstone of our work. Two NSCL graduate students received their Ph.D. in MoNA-related research and over 20 undergraduates from across the participating institutions of the collaboration were involved in research projects in 2012–2013. We also continue to keep a keen eye to the future, making preparations for our experimental program to be a possible "Day One" user of the new Facility for Rare Isotope Beams (FRIB), currently slated for completion in 2022.

Robert Kaye
Executive Director, the MoNA Collaboration
Beaver Island, MI, August 17, 2013

The MoNA (Modular Neutron Array) Collaboration continued to find success over the past year. To date, we have 37 peer reviewed papers with over half of those having undergraduate students as co-authors. In 2014 three graduate students completed their PhDs and another has data in hand to study the energy gap between the sd–pf neutron shells in ^{25}O. This year the total number of MoNA Collaboration undergraduate students has surpassed our lucky number of 144 – the number of neutron detectors in MoNA or LISA. Our 147 undergraduate students have presented over fifty times at national physics conferences. The infrastructure of the MoNA Collaboration and the tradition of expecting quality work from our students at all levels of their academic careers has led to our improving research opportunities and preparing the next generation of physicists.

Sharon Stephenson
Executive Director, the MoNA Collaboration
East Lansing, MI July 20, 2014

At the time of this 2016 MoNA (Modular Neutron Array) Report, our collaboration remains as strong as ever. Since we first began 13 years ago using MoNA for nuclear physics experiments, we have published 40 peer reviewed articles, primarily in Physical Review

Letters, Physical Review C, Physics Letters B, Nuclear Physics A, and Nuclear Instruments and Methods A, with over half of them including undergraduate co-authors. Recent scientific highlights of our group's work include a study of neutron correlations in the decay of excited ^{11}Li, selective population of unbound states in ^{10}Li, population of ^{13}Be using charge-exchange reactions, characterization of low-lying states in ^{12}Be, a search for unbound ^{15}Be states using the ^{12}Be + 3n channel, three-body correlations in the decay of the ^{26}O ground state, analysis of ^{10}He production mechanism using a ^{14}Be secondary beam and a deuterated target, and a measurement of the low-lying excited states of ^{24}O (which served as the LISA commissioning run). Recently completed experiments under analysis include a study of the of the equation of state using rare isotope beams, knockout reactions on p-shell nuclei, and in summer 2015 an experiment to measure the ground state energy of ^{10}He using two separate production mechanisms was completed. Approved experiments for the near future include a measurement of the ^{9}He ground state, and lifetime measurements with a decay-in-target method. To date 8 graduate students have completed their PhD degrees in MoNA research, 2 will be completing them soon, and 3 are relatively new to the group. By now 159 undergraduate students have participated in MoNA research, and have presented their research 56 times at national physics conferences. And for the first time our summer working retreat workshop was held outside of the state of Michigan, in sunny Santa Barbara, CA. The main goal of our collaborative effort is the execution of high quality research in nuclear science, with undergraduate participation at the heart of our efforts. This vision will continue to drive our efforts in future years with a shared goal of helping inspire and prepare the next generation of physicists.
Warren Rogers
Executive Director, the MoNA Collaboration
Santa Barbara, CA, July 31, 2015

The MoNA collaboration had another successful year and has been busily preparing for the completion of FRIB and the eventual construction of the High Rigidity Spectrograph. The addition of our active target system allows for experiments with even more exotic nuclei, and the system saw its first use in an experiment to measure the groundstate lifetime of ^{26}O. The collaboration continues to do cutting edge science in the structure and reactions of the most neutron-rich nuclei accessible. Beyond the scientific and technical the project continues to shape the careers of students, post-doctoral researchers, and faculty alike. The collaboration has touched the lives and careers of 171 undergraduates, who have participated in the running and analysis of our experiments or the construction of the detectors. This work has resulted in 44 peer-reviewed publications and many conference presentations, proceedings, and CEU posters. The collaboration remains vibrant and effective.
James Brown
Executive Director, the MoNA Collaboration
Crawfordsville, IN, August 13, 2016

The MoNA collaboration had another successful year of science and education, and we have also been presented with future challenging technical and personnel changes. In July the entire Collaboration, including 12 undergraduates, conducted an experiment to measure the 9He ground and excited states. We are now busy preparing in late November to look for neutron unbound states in the island of inversion. This will possibly be our last experiment in the N2 vault. To permit the testing of a CycStopper, we were asked to move the MoNA LISA detectors and Sweeper. In order to continue our scientific program we developed a plan to place our devices in front of the S800. We submitted a Letter of Intent to PAC 41 and they recognized and agreed with our proposal that this "would enable interesting studies on the nuclear structure and reactions involving the population of neutron-unbound excited states in medium mass neutron-rich nuclei, by giving improved PID resolution necessary to identify higher mass fragments." To stimulate interest in an experimental MoNA LISA/Sweeper/S800 campaign, the Collaboration led a Working Group at the 2017 Low Energy Community Meeting where six potential experiments were presented and discussed. We will be busy leading up to PAC 42 in March of 2018 writing proposals and addressing the technical issues for this experimental campaign.

Sadly, in mid-June Michael Thoennessen informed us that the APS Board of Directors approved his appointment as the new APS Editor in Chief. This is a great honor and opportunity for Michael. We are proud of him. But we are very sad to see him go. Without Michael there would be no MoNA collaboration and nearly 200 undergraduate students would have missed an unparalleled scientific opportunity. While we are indebted to him for his scientific leadership, we will mostly miss him as a friend.
Joe Finck
Executive Director, the MoNA Collaboration
Gull Lake, Michigan, August 12, 2017

The National Superconducting Cyclotron Laboratory is in its last years of operation and the construction of its upgrade, the Facility for Rare Isotope Beams, is near completion with an expected start date around 2021/2022. The MoNA collaboration has established itself as one of the most successful collaboration with unprecedented impact in undergraduate physics training (more than 200) through its decade of existence. Over the past year, the Collaboration achieved several milestones toward its transition from NSCL to FRIB science. One experiment to study neutron unbound states in the island of inversion was completed in the Fall 2017 and another experiment was approved by the PAC42

centered on the MoNA/LISA neutron detector arrays. A NSF/MRI to build a Si/CsI based telescope was awarded (N. Frank, PI) to improve the identification of heavy fragments. The expertise of the MoNA Collaboration also started expanding its impact on non-MoNA science at NSCL by participating in the SUN experiment over the Summer 2018 (P. DeYoung). The MoNA/LISA campaign in the N2 vault has ended after 14 years of operation. The entire experimental setup is being moved to the S2 vault for a future exciting and productive research program. The Collaboration contributed to the 2018 Nuclear Structure and Low Energy Community Conferences over the Summer with posters and oral presentations highlighting its research and impact in the field of fast neutrons science, and several students and faculty will be attending and presenting at the 2018 DNP meeting in the Fall. FRIB has initiated the investigation of an upgrade from 200 MeV/u to 400 MeV/u and the Collaboration is making plans for new detectors. P. Gueye has accepted a new position with FRIB/MSU. Through this new appointment, the MoNA Collaboration is reorganizing itself to grow its science for a bright future.
Paul Gueye
Executive Director, the MoNA Collaboration
NSCL/FRIB, East Lansing, August 12, 2018

Summer of 2019 finds the MoNA Collaboration looking back at a successful year and looking forward to a variety of challenges and opportunities. A number of our Ph.D. students are completing their degrees and starting the next chapter in their careers. Our undergraduate students are making meaningful contributions to our publications and well-positioned for graduate programs and STEM fields. Faculty have reached milestones, changed home institutions, and been awarded federal funding for our work. Over the past year we have dealt with physical changes – a large-scale move from one experimental area to another, detector development and data acquisition upgrades, as well as planning for new experiments – two at the NSCL/FRIB and one at Los Alamos National Laboratory. Our productivity is tied to our group's commitment to educating the next generation of scientists while pursuing new and exciting physics. We anticipate an exciting year ahead!

Sharon Stephenson
Executive Director, the MoNA Collaboration
National Superconducting Cyclotron Laboratory, July 19, 2019

The year 2020 will be remembered historically as the year of COVID-19. The low energy nuclear physics community will also remember it as the end of the NSCL era. The final two MoNA experiments at the NSCL were scheduled for summer 2020 but due to the pandemic were delayed. The Collaboration anticipates running at least one of the two approved experiments before the NSCL shuts down in an unfortunately shortened run schedule. As one era ends another begins. The MoNA Collaboration continues to plan and develop looking ahead to the FRIB era. This has been done through the development of next generation detectors, simulations, analysis techniques, and a deeper understanding of the MoNA bars. The Collaboration successfully ran a second experiment at LANSCE Fall 2019 and a test run at NSCL in Winter 2020 to commission the newly developed charged particle telescope. Three MoNA graduate students have defended their dissertations and have begun new jobs. Several undergraduate students have been involved and made an impact with many participating in the 2019 CEU program at the fall DNP meeting. There is a lot of uncertainty in the world right now, but the MoNA Collaboration has always found a way to rise to the occasion. This next year will be no exception.

Anthony Kuchera
Executive Director, the MoNA Collaboration
Davidson College by ZOOM, July 30, 2020

During this interim period between the NSCL shutdown and the start of full FRIB operations, and while the country and the world continue to struggle with the COVID-19 virus, the MoNA Collaboration has remained remarkably busy and productive. The collaboration conducted its final NSCL-based experiment in September 2020, and submitted three experiment proposals for the first round of experiments at FRIB. It has also been busy in active and polarized target design and construction, charged fragment telescope development and implementation for use in experiments without the Sweeper Magnet, DDAS development and implementation, Monte-Carlo simulation development, analysis of data from previous experiments for physics involving other isotope-neutron correlations, analysis of neutron scattering data from experiments at LANL, development of multi-neutron sorting algorithms and machine learning for datasets involving multi-neutron decays, and development of next generation neutron detectors and array designs for use at FRIB. Student and post-doctoral participation in MoNA remains strong, evidenced in part by the number of 2021 MoNA Collaboration meeting presentations given by 6 high school, 11 undergraduate, and 7 graduate students, as well as by 3 post-doctoral associates. The future of the MoNA Collaboration remains bright, ensured in large part by the significant quality and talent of our younger PIs, who as a group will help carry MoNA into the future. And as I pass executive leadership for this coming year to Nathan Frank, I am pleased to announce the addition of our newest PIs, Thomas Redpath and Calem Hoffmann. Despite the challenges of these past two years, the MoNA Collaboration remains strong.

Warren Rogers, Indiana Wesleyan University

Warren Rogers
Executive Director, the MoNA Collaboration
Indiana Wesleyan University by ZOOM, August 2, 2021

FRIB officially started operations in 2022 and the MoNA Collaboration is actively preparing for the future. The collaboration has spent the year preparing to run two experiments, 30F and 53Ca, which were accepted by PAC1 at FRIB and likely will run in early 2024. Working groups were formed along topics of Experiment Infrastructure, Detector Systems, Data Acquisition, Simulation and Analysis Software, PAC1 Project Planning, and Electronic Communication and Documentation, to make sure that we are ready for these experiments. In addition to future preparations, the collaboration worked on an analysis of 13Be data using a sweeper-less setup, analysis of data from previous experiments for physics involving other isotope-neutron correlations, analysis of new neutron scattering data from experiments at LANL, development of multi-neutron sorting algorithms and machine learning for datasets involving multi-neutron decays. The two-day annual MoNA Collaboration retreat included Primary Investigators (PIs), graduate students, undergraduate students, and high school students that contributed to the MoNA research program over the last calendar year presenting on the topics listed above along with a discussion of PAC2 proposal ideas and the next generation neutron detector among other new experimental devices. We welcomed a new PI Adriana Banu (James Madison University) as a full member of the Collaboration as one of eight collaborators on the Next Generation Neutron Detector and welcomed back PI Michael Thoennessen. With the growth of the collaboration and hard work of this year, the next Executive Director Thomas Redpath will ensure that we are successful in preparations for the first experiments at FRIB.

Nathan Frank
Executive Director, the MoNA Collaboration
FRIB, East Lansing Michigan, August 15–16, 2022

7 Presentations, Publications, Experiments, Grants

7.1 Invited Talks

1. The Modular Neutron Array at the NSCL
   T. Baumann for the MoNA Collaboration
   CAARI 2002: 17th International Conference on the Application of Accelerators in Research and Industry, CAARI, Denton TX, November 12–16, 2002

2. The MoNA project: doing big science projects with small-college undergraduates
   B. Luther
   APS April Meeting, Denver, CO, April 21–23, 2004; Bull. Am. Phys. Soc. 49, No. 2, 152 (2004)

3. Explorations of the driplines and first results from MoNA
   M. Thoennessen
   International Conference on Frontiers In Nuclear Structure, Astrophysics, and Reactions (FINUSTAR), Kos, Greece, September 12–17, 2005

4. Studies of neutron-rich nuclei with the MoNA/Sweeper system at the NSCL
   P. A. DeYoung
   APS April Meeting, Dallas, TX, April 22–25, 2006; Bull. Am. Phys. Soc. 51, No. 2, 24 (2006)

5. First excited state of doubly-magic ^{24}O
   A. Schiller, N. Frank, T. Baumann, J. Brown, P. DeYoung, J. Hinnefeld, R. Howes, J.-L. Lecouey, B. Luther, W. A. Peters, and M. Thoennessen
   Nuclear Structure 2006, Oak Ridge, TN, July 24–28, 2006; Book of Abstracts, Nuclear Structure 2006, Oak Ridge, p. 144 (2006)

6. Unbound states of neutron-rich oxygen isotopes
   M. Thoennessen, T. Baumann, D. Bazin, J. Brown, P. A. DeYoung, J. E. Finck, N. Frank, A. Gade, J. Hinnefeld, C. R. Hoffman, R. Howes, J.-L. Lecouey, B. Luther, W. A. Peters, W. F. Rogers, H. Scheit, A. Schiller, S. L. Tabor, MoNA Collaboration
   9th Int. Spring Sem. on Nucl Phys., Changing Facets of Nuclear Structure, Vico Equense, Italy, May 20–24, 2007; Abstracts, p. 2 (2007)

7. Unbound states of neutron-rich oxygen isotopes: Investigation into the N = 16 shell gap
   C. R. Hoffman, T. Baumann, D. Bazin, J. Brown, P. A. DeYoung, J. E. Finck, N. Frank, A. Gade, J. Hinnefeld, R. Howes, B. Luther, W. A. Peters, W. F. Rogers, H. Scheit, A. Schiller, S. L. Tabor, M. Thoennessen, MoNA Collaboration
   International Nuclear Physics Conference, INPC 2007, Tokyo, Japan, June 3–8, 2007; Program Book, F5-1, p. 14 (2007)

8. Unbound states of neutron-rich oxygen isotopes
   M. Thoennessen, T. Baumann, D. Bazin, J. Brown, P. A. DeYoung, J. E. Finck, N. Frank, A. Gade, J. Hinnefeld, C. R. Hoffman, R. Howes, J.-L. Lecouey, B. Luther, W. A. Peters, W. F. Rogers, H. Scheit, A. Schiller, S. L. Tabor, MoNA Collaboration
   International Conference on Proton Emitting Nuclei and Related Topics, PROCON07, Lisbon, Portugal, June 17–23, 2007; Abstracts, p. 54 (2007)

9. Unbound states of neutron-rich oxygen isotopes
   C. Hoffman
   JUSTIPEN-EFES workshop on shell structure of exotic nuclei 4th workshop by the DOE project JUSTIPEN and the JSPS core-to-core project EFES, RIKEN, Tokyo, Japan, June 23, 2007

10. Unbound states of neutron-rich oxygen isotopes: Investigation into the N = 16 shell gap
    C. R. Hoffman, T. Baumann, D. Bazin, J. Brown, P. A. DeYoung, J. E. Finck, N. Frank, A. Gade, J. Hinnefeld, R. Howes, B. Luther, W. A. Peters, W. F. Rogers, H. Scheit, A. Schiller, S. L. Tabor, M. Thoennessen, MoNA Collaboration
    International Conference on Nuclear Structure: Nuclear Structure: New Pictures in the Extended Isospin Space, Yukawa Institute for Theoretical Physics, Kyoto University, Kyoto, Japan, June 11–14, 2007; Book of Abstracts, p. 43 (2007)

11. Unbound states of neutron-rich oxygen isotopes: Investigation into the N = 16 shell gap
    C. Hoffman
    Direct Reactions with Exotic Beams, RIKEN, Tokyo, Japan, May 30–June 2, 2007

12. Proton knock-out reactions to neutron unbound states
M. Thoennessen
Workshop on Future Prospects for Spectroscopy and Direct Reactions, Michigan State University, East Lansing, MI, February 26–28, 2008

13. Investigating the N = 16 shell closure at the oxygen dripline
C. Hoffman
Nuclear Structure 2008, Michigan State University, East Lansing, MI, June 3–6, 2008

14. Neutron-decay spectroscopy of neutron-rich oxygen isotopes
M. Thoennessen, C. R. Hoffman, T. Baumann, D. Bazin, J. Brown, G. Christian, P. A. DeYoung, J. E. Finck, N. Frank, J. Hinnefeld, R. Howes, P. Mears, E. Mosby, S. Mosby, J. Reith, B. Rizzo, W. F. Rogers, G. Peaslee, W. A. Peters, A. Schiller, M. J. Scott, S. L. Tabor, P. J. Voss, and T. Williams
5th International Conference ENAM08 on Exotic Nuclei and Atomic Masses, Ryn, Poland September 7–13, 2008; Abstracts, p. 30 (2008)

15. Spectroscopy of unbound states at the oxygen drip line
C. Hoffman
Unbound Nuclei Workshop, INFN, Pisa, Italy, November 3–5, 2008

16. Big physics and small colleges: The mongol horde model of undergraduate research
B. Luther
AAPT Winter Meeting, Chicago, IL, Feb. 12–16, 2009; Program Guide, BA03, p. 47 (2009)

17. Exploration of the neutron drip-line at the NSCL
M. Thoennessen
Annual NuSTAR Meeting, March 23–27, 2009, GSI, Darmstadt, Germany

18. Explorations of the driplines
M. Thoennessen
Step Forward to FRIB, RIA/FRIB Workshop, May 30–31, 2009, Argonne, IL

19. Shell evolution at the oxygen drip line
C. Hoffman
VIII Latin American Symposium on Nuclear Physics and Applications, Universidad de Chile, Santiago, Chile, December 15–19, 2009

20. Unbound systems along the neutron drip line
A. Spyrou
Workshop on Perspectives on the modern shell model and related experimental topics, Michigan State University, East Lansing, MI, February 4–6, 2010

21. Dissertation award in nuclear physics
C. Hoffman
American Physical Society April Meeting, Washington, D. C., February 13–16, 2010

22. Exploration of the neutron dripline and discovery of new isotopes
M. Thoennessen
Carpathian Summer School of Physics 2010, June 20–July 3, 2010, Sinaia, Romania

23. Beyond the driplines with nuclear reactions
M. Thoennessen
24th International Nuclear Physics Conference, July 4–9, 2010, Vancouver, Canada

24. Undergraduate research with the MoNA Collaboration at the National Superconducting Cyclotron Laboratory
B. Luther
21st International Conference on the Application of Accelerators in Research and Industry, CAARI, Fort Worth, TX, Aug. 8–13, 2010

25. Neutron decay spectroscopy at and beyond the limit of stability
A. Spyrou
The Limits of Existence of Light Nuclei, ECT* Workshop, October 25–30, 2010, Trento, Italy

26. Nuclear structure physics with MoNA-LISA
S. L. Stephenson, J. A. Brown, P. A. DeYoung, J. E. Finck, N. H. Frank, J. D. Hinnefeld, R. A. Kaye, G. F. Peaslee, D. A. Meyer, W. F. Rogers, and the MoNA Collaboration
19th International Seminar on Interaction of Neutrons with Nuclei: Fundamental Interactions & Neutrons, Nuclear Structure, Ultracold Neutrons, Related Topics, JINR, Dubna, Russia, May 25–28, 2011

27. New experimental work on structure beyond the neutron drip-line
A. Spyrou
Nuclear Chemistry Gordon Research Conference, Colby-Sawyer College, New London, NH, June 12–17, 2011

28. Going beyond the dripline with MoNA-LISA
M. Thoennessen
1st Topical Workshop on Modern Aspects in Nuclear Structure Advances in Nuclear Structure with arrays including new scintillator detectors, February 22–25, 2012, Bormio, Italy

29. Exploration of light unbound nuclei
M. Thoennessen
Zakopane Conference on Nuclear Physics, August 27–September 2, 2012, Zakopane, Poland

30. Correlated two-neutron emission of nuclei beyond the neutron dripline
M. Thoennessen
4th International Conference on Collective Motion in Nuclei under Extreme Conditions COMEX 4, October 22–26, 2012, Shonan Village Center, Kanagawa, Japan

31. Recent results from MoNA-LISA
Artemisia Spyrou
D12.00003, American Physical Society April Meeting, Atlanta, GA, Bull. Am. Phys. Soc. 57 (2012)

32. Nuclear structure physics beyond the neutron drip line
Artemisia Spyrou
1WA.00001, Division of Nuclear Physics Fall Meeting, Newport Beach, CA, Bull. Am. Phys. Soc. 57 (2012)

33. Evidence for the ground-state resonance of ^{26}O.
Zachary Kohley
Direct Reactions with Exotic Beams (DREB) Workshop, Pisa, Italy, March 2012

34. Nuclear structure along the neutron drip line
A. Spyrou
8^{th} Balkan School on Nuclear Physics, Bulgaria, July 3-12, 2012

35. Nuclear structure experiments beyond the neutron drip line
Michael Thoennessen
International Nuclear Physics Conference (INPC2013), Florence Italy, 2 - 7 June 2013

36. Measuring oxygen isotopes beyond the neutron dripline: Two-neutron emission and radioactivity
Zachary Kohley
APS Division of Nuclear Physics Fall Meeting, Newport News, VA, October, 2013

37. Simulation of a novel active target for neutron-unbound state measurements
Nathan Frank Abstract DJ.00009, APS Division of Nuclear Physics Fall Meeting, Newport News, VA, October, 2013

38. Structure and decay correlations of two-neutron unbound systems beyond the dripline
Zachary Kohley
State of the Art in Nuclear Cluster Physics Workshop (SOTANCP3), Yokohama, Japan, May 2014

39. Three-body forces in two neutron decay experiments
A. Spyrou
ECT* Workshop: “Three-body forces: From Matter to Nuclei” Trento, Italy, 5-9 May, 2014

40. Study of neutron-unbound states with MoNA-LISA
M. Thoennessen
8^{th} International Workshop on Direct Reactions with Exotic Beams, June 30 - July 4, 2014, Darmstadt, Germany

41. Recent results from MoNA-LISA
M. Thoennessen
VII International Symposium on Exotic Nuclei, September 7-12, 2014, Kaliningrad, Russia

42. Neutron-unbound nuclei
M. Thoennessen
4^{th} Joint Meeting of the APS Division of Nuclear Physics and the Physical Society of Japan, Oct. 7-11, 2014, Waikoloa, HI

43. Direct Reactions with MoNA-LISA.
A. Kuchera,
Abstract B3.00002, APS April Meeting 2016, April 16-19, 2016, Salt Lake City, UT.

44. Identification of multiple neutrons with MoNA.
A. Kuchera,
Direct Reactions with Exotic Beams, Halifax, NS, Canada, July 11-15, 2016.

45. Reaction Mechanism Dependence of the Population and Decay of ^{10}He.
M. Thoennessen
International Nuclear Physics Conference, Adelaide, Australia, September 11-16, 2016.

46. Identification of multiple neutrons with MoNA.
A. Kuchera
Direct Reactions with Exotic Beams 2016, Halifax, Nova Scotia, Canada, July 11-15, 2016.

47. Direct Reactions with MoNA-LISA
A. Kuchera
APS April Meeting 2016, Salt Lake City, UT, April 16-19, 2016.

48. The Value of Undergraduate Research Participation in Physics, and in National DNP Meetings via the Conference Experience for Undergraduates. (APS Prize to a faculty member for research in an undergraduate institution)
Warren Rogers
U05.00001, American Physical Society April Meeting, Columbus, OH, Bull. Am. Phys. Soc. (2018).

49. Two Decadal Survey of Unbound Nuclei with the Mona-lisa Detector: Past, Present and Future Outlook.
P. Guèye
1WKA.00003, 5th Joint Meeting of the APS Division of Nuclear Physics and the Physical Society of Japan. Waikoloa, HI October 23-27, 2018.

50. Latest news from the MoNA Collaboration at NSCL
T. Baumann
NUSTAR Annual Meeting, Darmstadt, Germany, February 25–March 1, 2019

51. Another FRIB Impact: Is Tomography of Heavy Ions Experimentally Possible?
Paul Guèye
NSCL Nuclear Science Seminar, March 18, 2019

52. MoNA and Dripline Search
Paul Guèye
NSCL/NSF Site Review, August 2019

53. Welcoming remarks (co-organizer)
Paul Guèye
Geant4 Collaboration Meeting, September 26–28, 2019

54. Welcoming/Goals (co-organizer)
Paul Guèye
JINA-CEE Minority Serving Institutions Workshop, December 14, 2019

55. MoNA-LISA: drip-oil painting with Leonardo da Vinci to drip-line with FRIB
Paul Guèye, MSU
FRIB Staff Talk, January 8, 2020

56. Un Voyage Dans la Vie des Nucléons
Paul Guèye
Université Cheikh Anta Diop, Sénégal, Africa, February 26, 2020

57. The (Hidden) Shades of Physics - Perspectives of being a Black Physicist
Paul Guèye, MSU
Women and Minorities in Science Lecture Series, Michigan State University, August 5, 2020

58. MoNA in HRS
Paul Guèye, MSU
Low Energy Community Meeting, August 10–12, 2020

59. Probing the neutron dripline: challenges and prospects
Belen Monteagudo Godoy, MSU
Bull. Am. Phys. Soc. FP.00001, Fall Meeting of the APS Division of Nuclear Physics, virtual (2020).

60. Partnerships with Minority Serving Colleges and Universities
Paul Guèye, MSU
Low Energy Community Meeting, August 10–12, 2020.

61. MoNA-LISA
Thomas Baumann
Auxiliary Detectors and GRETA Workshop, December 10–11, 2020.

62. Structure of exotic nuclei out to the limits of existence
Anthony Kuchera
88^{th} Annual Meeting of the APS Southeastern Section, Tallhassee, Fl, November 18-20, (2021)

63. Understanding neutron scattering in plastic scintillators and the future of MoNA
Anthony Kuchera
CENTAUR-JINPA Neutron Detector Workshop, Virtual, September 29 - October 1, (2021)

64. 3n decay from ^{15}Be
Anthony Kuchera
Neutron-Unbound Systems Around the Dripline, Virtural, FRIB hosted, July 13-14, (2021)

65. Probing open quantum systems with open questions using rare isotopes along the dripline at high energies.
Paul Gueye
Kavli Institute for Theoretical Physics Conference: Opportunities and Challenges in Few-Body Physics: Unitarity and Beyond, May 25, 2022

66. MoNA-LISA at FRIB
Thomas Baumann and Paul Gueye
Invariant mass spectroscopy with MoNA- LISA pre-HRS Working Group Session, Low Energy Community Meeting 2022 August 9, 2022

67. The Future of MoNA at FRIB
Anthony Kuchera
Halo Week 2022, Bergen, Norway, July 10-15, 2022
`https://indico.gsi.de/event/12277/`

68. Resonance Phenomena at the Edges of Stability
N. Frank
NSAC Long Range Plan Town Hall Meeting on Nuclear Structure, Reactions, and Astrophysics, Nuclear Experiment Working Group, Argonne National Laboratory, November 14-16, (2022)

69. Neutron-Unbound States of Nuclides within the Island of Inversion
N. Frank
Virtual Nuclear Seminar, Department of Physics, University of Massachusetts Lowell, Lowell, MA, November 3, (2022)

70. White Paper on Nuclear Structure, Reactions, and Astrophysics
A. Gade, S. Quaglioni, G. Rogachev, and R. Surman et al.
Nuclear Science Advisory Committee Long Range Plan Town Hall Meeting, Nov. 14-16, 2022, Argonne National Lab, February 26, (2023)

7.2 Talks and Posters at Conferences

1. MONA: The Modular Neutron Detector
B. Luther, T. Baumann, M. Thoennessen, J. Brown, P. DeYoung, J. Finck, J. Hinnefeld, R. Howes, K. Kemper, P. Pancella, G. Peaslee, and W. Tabor
Abstracts, 10^{th} Symposium on Radiation Measurements and Applications, p. 58 (2002)

2. Improving neutron detection efficiency by using passive converters
T. Baumann, H. Ikeda, M. Kurokawa, M. Miura, T. Nakamura, Y. Nishi, S. Nishimura, A. Ozawa, T. Sugimoto, I. Tanihata and M. Thoennessen
Abstracts, 10^{th} Symposium on Radiation Measurements and Applications, p. 59 (2002)

3. MONA: The Modular Neutron Detector
B. Luther, T. Baumann, M. Thoennessen, J. Brown, P. DeYoung, J. Finck, J. Hinnefeld, R. Howes, K. Kemper, P. Pancella, G. Peaslee, and S. Tabor
Program of the Conference on Frontiers of Nuclear Structure, FNS2002, p. 109, LBNL-50598 Abs. (2002)

4. Construction of a Modular Neutron Array (MoNA)—A multi-college collaboration
W. F. Rogers, T. Baumann, J. Brown, P. DeYoung, J. Finck, J. D. Hinnefeld, R. Howes, K. Kemper, B. A. Luther, P. Pancella, G. F. Peaslee, S. Tabor, M. Thoennessen
Bull. Am. Phys. Soc. 47, No. 6, 27 (2002)

5. The status of the MoNA project
T. Baumann, MoNA Collaboration
Bull. Am. Phys. Soc. 48, No. 8, 47 (2003)

6. MoNA: Detector development as undergraduate research
Ruth Howes
Workshop on Detector Development, Bloomington, IN, May 30, 2003

7. FPGA-based trigger logic for the Modular Neutron Array (MoNA)
T. Baumann, P. A. DeYoung, MoNA Collaboration
Bull. Am. Phys. Soc. 49, No. 2, 181 (2004)

8. Commissioning of the MSU/FSU sweeper magnet
N. Frank, M. Thoennessen, W. A. Peters, T. Baumann, D. Bazin, J. DeKamp, L. Morris, D. Sanderson, A. Schiller, J. Yurkon, A. Zeller, R. Zink
Bull. Am. Phys. Soc. 49, No. 6, 20 (2004)

9. Characteristics and preliminary results from MoNA at MSU/NSCL
W. A. Peters, N. Frank, M. Thoennessen, T. Baumann, J. Brown, D. Hecksel, P. DeYoung, T. Pike, J. Finck, P. Voss, B. Luther, M. Kleber, J. Miller, R. Pipen, W. Rogers, L. Elliott, M. Strongman, K. Watters, MoNA Collaboration
Bull. Am. Phys. Soc. 49, No. 6, 20 (2004)

10. How undergraduates from four-year departments can do “big” physics
R. Howes for the MoNA Collaboration
The Announcer 34, No. 4, 93 (2004)

11. Excitation and decay of neutron-rich Be isotopes
W. Peters, MoNA Collaboration
Book of Abstracts, International Conference on Direct Nuclear Reactions with Exotic Beams, DREB05 (2005)

12. Ground state wave function of ^{12}Be
W. A. Peters, T. Baumann, N. Frank, J.-L. Lecouey, A. Schiller, M. Thoennessen, K. Yoneda, P. DeYoung, G. Peaslee, J. Brown, K. Jones, B. Luther, and W. Rogers
Bull. Am. Phys. Soc. 50, No. 6, 85 (2005)

13. Search for the first excited state of ^{24}O
N. Frank, P. G. Hansen, J.-L. Lecouey, W. A. Peters, A. Schiller, C. Simenel, J. R. Terry, M. Thoennessen, K. Yoneda, P. DeYoung, J. Brown, J. Hinnefeld, R. Howes, R. A. Kryger, B. Luther
Bull. Am. Phys. Soc. 50, No. 6, 86 (2005)

14. First excited state of doubly-magic ^{24}O
N. Frank, A. Schiller, T. Baumann, J. Brown, P. DeYoung, J. Hinnefeld, R. Howes, J.-L. Lecouey, B. Luther, W. A. Peters, M. Thoennessen
Bull. Am. Phys. Soc. 51, No. 6, 21 (2006)

15. Population of neutron-unbound states from direct fragmentation
G. Christian, D. Bazin, N. Frank, A. Gade, B. Golding, W. Peters, A. Ratkiewicz, A. Stump, A. Stolz, M. Thoennessen, M. Kleber, J. Miller, J. Brown, T. Williams, J. Finck, P. DeYoung, J. Hinnefeld, MoNA Collaboration
Bull. Am. Phys. Soc. 51, No. 6, 74 (2006)

16. Detection efficiency of the Modular Neutron Array
T. Baumann, W. A. Peters, MoNA Collaboration
Bull. Am. Phys. Soc. 51, No. 6, 103 (2006)

17. Cosmic muon detection using the NSCL Modular Neutron Array
W. F. Rogers, S. Mosby, S. Mosby, J. Gillette, M. Reese, MoNA Collaboration
Bull. Am. Phys. Soc. 51, No. 6, 103 (2006)

18. Study of Coulomb and nuclear dissociation for astrophysical neutron capture cross sections
A. Horvath, K. Ieki, A. Kiss, A. Galonsky, M. Thoennessen, T. Baumann, D. Bazin, C. A. Bertulani, C. Bordeanu, N. Carlin, M. Csanad, F. Deak, P. DeYoung, N. Frank, T. Fukuchi, Zs. Fulop, A. Gade, D. R. Galaviz, C. Hoffman, R. Izsak, W. A. Peters, H. Schelin, A. Schiller, R. Sugo, Z. Seres, and G. I. Veres
Book of Abstracts, IX International Conference on Nucleus Nucleus Collisions (NN2006), p. 236 (2006)

19. Ground state of ^{25}O and the first excited state of ^{24}O
C. R. Hoffman, S. Tabor, T. Baumann, D. Bazin, A. Gade, W. A. Peters, H. Scheit, A. Schiller, M. Thoennessen, J. Brown, P. A. DeYoung, J. E. Finck, J. Hinnefeld, R. Howes, N. Frank, B. Luther, MoNA Collaboration
Bull. Am. Phys. Soc. 52, No. 3, 198 (2007)

20. Unbound states of neutron-rich oxygen isotope
C. R. Hoffman, S. L. Tabor, M. Thoennessen, T. Baumann, D. Bazin, A. Gade, W. A. Peters, A. Schiller, J. Brown, P. A. DeYoung, R. Howes, N. Frank, B. Luther, H. Scheit, J. Hinnefeld, MoNA Collaboration
Bull. Am. Phys. Soc. 52, No. 9, 29 (2007)

21. Measurement of the ground state of ^{15}Be
A. Spyrou, T. Baumann, D. Bazin, G. Christian, S. Mosby, M. Strongman, M. Thoennessen, J. Brown, P. A. Deyoung, A. Deline, J. E. Finck, A. Russell, N. Frank, E. Breitbach, R. Howes, W. A. Peters, A. Schiller
Bull. Am. Phys. Soc. 53, No. 5, 114 (2008)

22. Investigating The N = 16 shell closure at the oxygen drip line
C. R. Hoffman, T. Baumann, D. Bazin, J. Brown, G. Christian, P. A. DeYoung, J. E. Finck, N. Frank, J. Hinnefeld, R. Howes, P. Mears, E. Mosby, S. Mosby, J. Reith, B. Rizzo, W. F. Rogers, G. Peaslee, W. A. Peters, A. Schiller, M. J. Scott, S. L. Tabor, M. Thoennessen, P. J. Voss, T. Williams
Book of Abstracts, 12th in series of nuclear structure 2008, Michigan State University, East Lansing, Michigan, June 3–6, 2008 p. 66 (2008)

23. Measurement of the efficiency of the Modular Neutron Array (MONA) at the NSCL
W. A. Peters, T. Baumann, M. Thoennessen, G. Christian, M. Strongman, N. Frank, P. A. DeYoung, A. Schiller
CAARI (2008)

24. Studying the structure of the neutron-unbound ^{12}Li
A. Spyrou, M. Thoennessen, P. A. DeYoung, C. C. Hall, and the MoNA Collaboration
Bull. Am. Phys. Soc. 53, No. 12, ED.00006 (2008)

25. Nuclear structure studies along the neutron drip line: The case of ^{22}N
A. Spyrou and the MoNA Collaboration
8th International Conference on Radioactive Nuclear Beams (RNB8), Grand Rapids, MI, USA, 26–30 May 2009

26. Studying the neutron unbound ^{18}B
A. Spyrou, T. Baumann, D. Bazin, G. Christian, S. Mosby, M. Strongman, M. Thoennessen, J. Brown, P. A. DeYoung, A. DeLine, J. E. Finck, A. Russel, N. Frank, E. Breitbach, R. Howes, W. A. Peters, A. Schiller, MoNA Collaboration
Bull. Am. Phys. Soc. 54, No. 10, LH.00004 (2009)

27. Disappearance of the N = 14 shell
M. J. Strongman, T. Baumann, D. Bazin, N. Frank, S. Mosby, W. A. Peters, A. Schiller, A. Spyrou, M. Thoennessen, C. R. Hoffman, S. L. Tabor, J. Brown, P. A. DeYoung, J. E. Finck, W. F. Rogers
Bull. Am. Phys. Soc. 54, No. 10, LL.00003 (2009)

28. Creating a collaboration to perform big science at small schools
Joseph E. Finck, Bryan Luther, and Graham Peaslee
CUR 13th Nation Conference, Undergraduate Research as Transformative Practice, June 19–22, 2010, Weber State University, Ogden UT

29. Impact of undergraduate research experiences on graduate research programs (panel discussion)
Michael Thoennessen
Bull. Am. Phys. Soc. 55, No. 1, April Meeting of the APS, Washington, D.C., G6.00004 (2010)

30. Spectroscopy of neutron-unbound fluorine isotopes
G. Christian, N. Frank, S. Ash, M. Warren, A. Gade, A. Spyrou, M. Thoennessen, T. Baumann, G. F. Grinyer, D. Weisshaar, P. A. DeYoung, MoNA Collaboration
Bull. Am. Phys. Soc. 55, No. 14, MG.00008 (2010)

31. Ground-state neutron decay of ^{21}C
S. Mosby, M. Thoennessen, P. DeYoung
Bull. Am. Phys. Soc. 55, No. 14, DC.00003 (2010)

32. Nuclear structure along the neutron dripline
A. Spyrou, MoNA Collaboration
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33. Construction and testing of the Large multi-Institutional Scintillator Array (LISA) – A model of collaborative undergraduate research
Warren Rogers and the MoNA Collaboration
Bull. Am. Phys. Soc. 56, No. 4, B13.00004, APS Spring Meeting, Anaheim, CA (2011)

34. Spectroscopy of neutron unbound fluorine
Gregory Christian, N. Frank, S. Ash, M. Warren, A. Gade, A. Spyrou, M. Thoennessen, T. Baumann, G. F. Grinyer, D. Weisshaar, P. A. DeYoung, MoNA Collaboration
Bull. Am. Phys. Soc. 56, No. 4, B7.00005 (2011)

35. Measurement of excitation energy of neon prefragments
M. Mosby, D. J. Morrissey, M. Thoennessen
Bull. Am. Phys. Soc. 56, No. 12, ME.00004 (2011)

36. Spectroscopy of neutron unbound carbon isotopes
S. Mosby, M. Thoennessen, P. DeYoung
Bull. Am. Phys. Soc. 56, No. 12, JF.00002 (2011)

37. Spectroscopy of neutron-unbound ^{15}Be
Jesse Snyder, Michael Thoennessen, Thomas Baumann, Artemis Spryou, Michael Strongman, Greg Christian, Shea Mosby, Michelle Mosby, Jenna Smith, Anna Simon, Bryan Luther, Sharon Stephenson, Alex Peters, Paul DeYoung, Eric Lunderberg, Joseph Finck
Bull. Am. Phys. Soc. 56, No. 12, JF.00001 (2011)

38. Fast fragmentation studies with the MoNA and LISA neutron detectors
Joseph E. Finck and the MoNA Collaboration
XII International Symposium on Nuclei in the Cosmos, Cairns, Australia (August 5–10, 2012)

39. Unbound excited states in ^{28}Ne and ^{25}F
Jenna Smith, B. Alex Brown, Greg Christian, Shea Mosby, John F. Novak, Steven J. Quinn, Jesse Snyder, Artemis Spyrou, Michael J. Strongman, Michael Thoennessen, Thomas Baumann, Zachary Kohley, Joseph E. Finck, and Calem R. Hoffman
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40. Spectroscopy of neutron-unbound ^{15}Be
Jesse Snyder, Michael Thoennessen, Thomas Baumann, Artemis Spryou, Michael Strongman, Greg Christian, Shea Mosby, Michelle Mosby, Jenna Smith, Anna Simon, Bryan Luther, Sharon Stephenson, Alex Peters, Paul DeYoung, Eric Lunderberg and Joseph Finck
CD.00009, Division of Nuclear Physics Fall Meeting, Newport Beach, CA (2012)

41. The controversial ^{10}He ground state resonance: A new observation using a 2p2n-removal from ^{14}Be
Z. Kohley, J. Snyder and M. Thoennessen
CD.00005, Division of Nuclear Physics Fall Meeting, Newport Beach, CA (2012)

42. Simulation of a novel active target for neutron-unbound state measurements
Nathan Frank
Abstract DJ.00009, APS Division of Nuclear Physics Fall Meeting, Newport News, VA, October, 2013

43. Measuring the partial width of the ^{56}Ni proton-capture resonance through (d,n) with VANDLE and MoNA-LISA
William Peters, R. Grzywacz, M. Madurga, S. Paulauskas, S. Taylor, J. Allen. J.A. Cizewski, B. Manning, M.E. Howard, D.W. Bardayan, S.D. Pain, R.C.C. Clement, S. Ilyushkin, P.D. O'Malley, R. Ikeyama, R.L. Kozub, K.D. Long, Z.J. Bergstrom, P.A. DeYoung, W.F. Rogers, J. Smith, M. Jones, T. Baumann, M. Thoennessen
Abstract CF.00001, APS Division of Nuclear Physics Fall Meeting, Newport News, VA, October, 2013

44. 4n contributions in populating unbound ^{10}He from ^{14}Be
Michael Jones, Zach Kohley, Jesse Snyder, Thomas Baumann, Jenna Smith, Artemis Spyrou, Michael Thoennessen
Abstract PD.00004, APS Division of Nuclear Physics Fall Meeting, Newport News, VA, October, 2013

45. Two-neutron decay of excited states of ^{11}Li
J. Smith, MoNA Collaboration
Abstract PD.00007, APS Division of Nuclear Physics Fall Meeting, Newport News, VA, Bull. Am. Phys. Soc. 58, No. 13, 152 (2013)

46. Measurement of neutron knockout cross-section of ^{24}O to the ground-state of ^{23}O
D. Divaratne, C. Brune, P. King, H. Attanayake, S. Grimes, M. Thoennessen, D. Bazin, MoNA Collaboration
Abstract PD.00008, APS Division of Nuclear Physics Fall Meeting, Newport News, VA, Bull. Am. Phys. Soc. 58, No. 13, 152 (2013)

47. Two-neutron decay from the ground state of ^{26}O
H. Attanayake, P. King, C. Brune, D. Diaratne, MoNA Collaboration
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48. A Multi-layered target for the study of neutron-unbound nuclei
Paul Gueye, Nathan Frank and Michael Thoennessen
D13.00002, American Physical Society Meeting, Denver, CO, Bull. Am. Phys. Soc. 58, No. 4, 67 (2013)

49. Measurement of neutron knockout cross section of ^{24}O to the ground-state of ^{23}O
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50. VANDLE-izing north america; first results from the versatile array of neutron detectors at low energy
W.A. Peters, M. Madurga, S. Paulauskas, R. Grzywacz, J.A. Cizewski, M.E. Howard, A. Ratkiewewicz, B. Manning, J. Blackmon, D.W. Bardayan, M.S. Smith, S. Ilyushkin, P.D. O'Malley, F. Sarazin, T. Baumann, M. Thoennessen, P.A. DeYoung, R.R.C. Clement, E. Stech, and M. Wiesher
INPC2013 Book of Abstracts, NF070 (2013)

51. Experimental check of Coulomb dissociation method for neutron capture measurements
R. Izsak, A. Galonsky, A. Horvath, A. Kiss, Z. Seres, M. Thoennessen, C.A. Bertulani, Zs. Fulop, T. Baumann, D. Bazin, K. Ieki, C. Bordeanu, N. Carlin, M. Csanad, F. Deak, P. DeYoung, N. Frank, T. Fukuchi, A. Gade, D. Galaviz, C. Hoffman, W.A. Peters, H. Schelin, A. Schiller, R. Sugo, and G.I. Veres
EuroGENESIS workshop on "Open problems and future directions in heavy element nucleosynthesis", Book of Abstracts, p. 31 (2013)

52. Determining the resonance strength of the ^{56}Ni *rp*-process waiting point through (d,n) with VANDLE and MoNA-LISA
W. Peters, R. Grzywacz, M. Madurga, S.V. Paulauskas, S. Taylor, J. Allen, J.A. Cizewski, B. Manning, M.E. Howard. J. Smith, M. Jones, T. Baumann, M. Thoennessen, D.W. Bardayan, S.D. Pain, R.C.C. Clement, J. Brown, B. Luther, S. Ilyushkin, P.D. O'Malley, R. Ikeyama, R.L. Kozub, Z.J. Bergstrom, P.A. DeYoung, W. Rogers
Abstract K6.00008, American Physical Society, Savannah, Georgia, April 2014

53. Search for ^{15}Be in the 3n+^{12}Be channel.
A. N. Kuchera, A. Spyrou, J. K. Smith, T. Baumann, G. Christian, P. A. DeYoung, J. E. Finck, N. Frank, M. D. Jones, Z. Kohley, S. Mosby, W. A. Peters, and M. Thoennessen.
The 21st International Few Body Conference on Few-Body Problems in Physics, Chicago, IL, May 18, 2015.

54. Search for 4n contributions in the reaction ^{14}Be(CH_2,X)^{10}He.
M. D. Jones and Z. Kohley, T. Baumann, G. Christian, P. A. DeYoung, N. Frank, R. A. Haring-Kaye, A. N. Kuchera, B. Luther, S. Mosby, J. Snyder, A. Spyrou, S. L. Stephenson, and M. Thoennessen.
The 21st International Few Body Conference on Few-Body Problems in Physics, Chicago, IL, May 18, 2015.

55. Knockout reactions on p-shell nuclei for tests of structure and reaction models.
A.N. Kuchera, D. Bazin, M. Babo, T. Baumann, M. Bowry, J. Bradt, J. Brown, P.A. DeYoung, B. Elman, J.E. Finck, A. Gade, G.F. Grinyer, M.D. Jones, E. Lunderberg, T. Redpath, W.F. Rogers, K. Stiefel, M. Thoennessen, D. Weisshaar, and K. Whitmore
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56. Direct Observation of Neutron Scattering in Plastic Scintillators.
A.N. Kuchera
Office of Defense Nuclear Nonproliferation Research and Development University and Industry Technical Interchange, Raleigh, NC, June 7-9, 2016.

57. Neutron multiplicity distributions for neutron-rich projectile fragments at the NSCL.
Maria Mazza, Peter Christ, and Sharon Stephenson
Bull. Am. Phys. Soc. **61**, EA.00115, Fall Meeting of APS DNP, Vancouver, BC, Canada, October 13-16, 2016.

58. Constraining the Symmetry Energy Using Radioactive Ion Beams.
Krystin Stiefel, Zachary Kohley, Dave Morrissey, and Michael Thoennessen
Bull. Am. Phys. Soc. **61**, HF.00007, Fall Meeting of APS DNP, Vancouver, BC, Canada, October 13-16, 2016.

59. Reaction Mechanism Dependence Of The Population And Decay Of ^{10}He.
Han Liu, Thomas Redpath, Michael Thoennessen, and the MoNA Collaboration
Bull. Am. Phys. Soc. **62**, H12.000005, APS April Meeting, Washington DC, January 28-31, 2017.

60. Lifetime Measurement of ^{26}O.
Thomas Redpath
Bull. Am. Phys. Soc. **62**, H12.000006, APS April Meeting, Washington DC, January 28-31, 2017.

61. Direct Observation of Neutron Scattering in MoNA Scintillator Detectors.
Rogers, W. F.; Mosby, S.; Frank, N.; Kuchera, A. N.; Thoennessen, M.; and the MoNA Collaboration
Bull. Am. Phys. Soc. **62**, H13.00002, APS April Meeting, Washington DC, January 28-31, 2017.

62. A multi-layered active target for the study of neutron-unbound nuclides at NSCL.
Jessica Freeman, Paul Gueye, and Thomas Redpath
Bull. Am. Phys. Soc. **62**, H13.000003, APS April Meeting, Washington DC, January 28-31, 2017.

63. The new Digital Data Acquisition System for MoNA-LISA.
Dayah Chrisman and Paul DeYoung
Bull. Am. Phys. Soc. **62**, H13.000004, APS April Meeting, Washington DC, January 28-31, 2017.

64. G4MoNA - A Geant4 Simulation for unbound nuclides detected with MoNA/LISA.
Paul Gueye, Jessica Freeman, and Nathan Frank
Bull. Am. Phys. Soc. **62**, H13.000005, APS April Meeting, Washington DC, January 28-31, 2017.

65. Determining fragmentation dynamics through a study of neutron multiplicity at the NSCL.
Sharon Stephenson, Peter Christ, and Maria Mazza
Bull. Am. Phys. Soc. **62**, J12.000002, APS April Meeting, Washington DC, January 28-31, 2017.

66. Development of a forward-angle gamma-ray detector array for MoNA-LISA.
Daniel Votaw
Bull. Am. Phys. Soc. **62**, M15.000003, APS April Meeting, Washington DC, January 28-31, 2017.

67. Selective Population of Unbound Positive Parity States in ^{25}F and ^{26}F.
Nathan Frank, Jacob Herman*, Ali Rabeh*, and Matthew Tuttle-Timm*
Bull. Am. Phys. Soc. **62**, Y13.000004, APS April Meeting, Washington DC, January 28-31, 2017.

68. Direct Observation of Neutron Scattering in BC408 Scintillator for Comparison with Simulation.
W. F. Rogers, J. E. Boone, A. Wantz, N. Frank, A. N. Kuchera, S. Mosby, and M. Thoennessen
Bull. Am. Phys. Soc. **62**, JD.00007, Fall Meeting of the APS DNP, Pittsburgh, PA, October 25-28, (2017).

69. Search for unbound nuclides and beam/fragment optics with the MoNA/LISA segmented target at NSCL.
Paul Gueye, Nathan Frank, Michael Thoennessen, Thomas Redpath
Bull. Am. Phys. Soc. **62**, PB.00005, Fall Meeting of the APS DNP, Pittsburgh, PA, October 25-28, (2017).

70. Development of a forward-angle gamma array for MoNA-LISA.
D. Votaw
Poster presented at NNSA UPR, Walnut Creek, CA, June 2017.

71. Measurement of ^{9}He ground and excited states.
D. Votaw
Poster presented at NSSC workshop, LBNL, September 2017.

72. Direct Neutron Scattering Observations in BC408 Scintillator, and Comparison to Simulation.
W.F. Rogers, J.E. Boone*, A. Wantz*, N. Frank, A.N. Kuchera, S. Mosby, M. Thoennessen
Bull. Am. Phys. Soc., MH.00011, 5th Joint Meeting of the APS Division of Nuclear Physics and the Physical Society of Japan, Waikoloa, HI, October 23-27, (2018).

73. A Dual Phase TPC/Thick-gem Based Target to Study Unbound Nuclei.
Angel C. Christopher, Paul L Gueye, Thomas Baumann, Marco Cortesi, Malinga Rathnayake
Bull. Am. Phys. Soc., DH.00011, 5th Joint Meeting of the APS Division of Nuclear Physics and the Physical Society of Japan, Waikoloa, HI, October 23-27, (2018).

74. Projectile-like fragment production studies using coincident neutrons.
Sharon Stephenson, the MoNA Collaboration
Bull. Am. Phys. Soc., MC.00009, 5th Joint Meeting of the APS Division of Nuclear Physics and the Physical Society of Japan, Waikoloa, HI, October 23-27, (2018).

75. Measurement of ^{9}He ground and excited states.
D. Votaw, P.A. DeYoung, T. Baumann, A.N. Kuchera, C.F. Persch*, Tan Phan*, M.R. Thoennessen, and the MoNA Collaboration,
Bull. Am. Phys. Soc., CB.00004, 5th Joint Meeting of the APS Division of Nuclear Physics and the Physical Society of Japan, Waikoloa, HI, October 23-27, (2018).

76. Neutron Unbound States in the Island of Inversion.
Dayah Chrisman, Thomas Baumann, Paul A Deyoung, Nathan Frank, Anthony N Kuchera, John McDonaugh, Robbie Seaton-Todd*, William vonSeeger*, the MoNA Collaboration,
Bull. Am. Phys. Soc., DD.00005, 5th Joint Meeting of the APS Division of Nuclear Physics and the Physical Society of Japan, Waikoloa, HI, October 23-27, (2018).

77. The MoNA-LISA research program at NSCL and FRIB.
Thomas Baumann, James Aaron Brown, Paul A DeYoung, Joseph Finck, Nathan Frank, Paul L Gueye, Jerry D Hinnefeld, Robert A Haring-Kaye, Anthony N Kuchera, Bryan A Luther, Warren F Rogers, Artemis Spyrou, Sharon L Stephenson, Michael R Thoennessen,
Bull. Am. Phys. Soc., LM.00004, 5th Joint Meeting of the APS Division of Nuclear Physics and the Physical Society of Japan, Waikoloa, HI, October 23-27, (2018).

78. The MoNA Collaboration Multi-Layered SI-BE Segmented Target: Impact On Neutron Rich Nuclei.
Paul L Gueye, Thomas Baumann, Dayah Chrisman, Paul A Deyoung, Nathan Frank, Anthony N Kuchera, Thomas H Redpath, Michael R Thoennessen, William von Seeger*,
Bull. Am. Phys. Soc., LM.00005, 5th Joint Meeting of the APS Division of Nuclear Physics and the Physical Society of Japan, Waikoloa, HI, October 23-27, (2018).

79. Geant4 study of the electric field effect on the signals from GEM detectors
Malinga Rathnayake
2018 National Society of Black Physicists annual meeting, Columbus, OH, November 4-7 (2018)

80. Measurement of ^{9}He ground and excited states.
D. Votaw
Poster presented at NNSA UPR, Ann Arbor, MI, June 2018.

81. Charged Particle Detector Telescope for Studies of Neutron-rich Systems.
Nathan Frank, Georgia Votta, Thomas Baumann, James Brown, Paul DeYoung, and the MoNA Collaboration
Bull. Am. Phys. Soc., SC.00004 Fall Meeting of the APS Division of Nuclear Physics, Crystal City, VA (2019).

82. Search for the ^{15}Be ground state.
Anthony Kuchera, Rida Shahid, Nathan Frank, Hayden Karrick*,
Bull. Am. Phys. Soc., FN.00009 Fall Meeting of the APS Division of Nuclear Physics, Crystal City, VA (2019).

83. Parity inversion in the unbound N = 7 isotones.
D. Votaw
NNSA UPR, Raleigh, NC, 2019.

84. Investigation of a Gas Phot-multiplier as a next generation neutron detector.
Maya Watts, Thomas Baumann, Marco Cortesi, Alder Fulton, Paul Gueye, Phuonghan Pham, and Thomas Redpath
Bull. Am. Phys. Soc. poster S01.00092, April Meeting of the American Physiscal Society, Washington DC, April 18-21, (2020).

85. Mirror nucleon removal reactions in p-shell nuclei
Anthony Kuchera, Tan Phan, Daniel Bazin, and the MoNA Collaboration
Bull. Am. Phys. Soc. KP.00001, Fall Meeting of the APS Division of Nuclear Physics, virtual (2020).

86. Neutron-Unbound States in the N=20 Island of Inversion
Dayah Chrisman, Thomas Baumann, Paul Gueye, Anthony Kuchera, Robbie Seaton-Todd, Nathan Frank, John McDonaugh, and the MoNA Collaboration
Bull. Am. Phys. Soc. FP.00003, Fall Meeting of the APS Division of Nuclear Physics, virtual (2020).

87. Physicists Inspiring the Next Generation: Exploring the Nuclear Matter
Yannick Gueye
Bull. Am. Phys. Soc. SE.00001, Fall Meeting of the APS Division of Nuclear Physics, virtual (2020).

88. Trace Fitting of a Charged Particle Telescope to use with MoNA
Georgia Votta, Nathan Frank, Thomas Baumann, Paul Gueye, Thomas Redpath, Belen Monteagudo Godoy, Anthony Kuchera, and the MoNA Collaboration
Bull. Am. Phys. Soc. EJ.00006, Fall Meeting of the APS Division of Nuclear Physics, virtual (2020).

89. A Search for the ^{12}Be Isomeric State.
XINYI WANG and the MoNA Collaboration
Bull. Am. Phys. Soc. B14.00004, APR21 meeting of the American Physical Society, virtual, (2021).

90. Nuclear Science Research and the Undergraduate Experience.
Warren Rogers
Workshop for Applied Nuclear Data Activities (WANDA 2021), https://conferences.lbl.gov/event/504/, 25 Jan. - 3 Feb., (2021)

91. A Next Generation Neutron Detector.
Thomas Baumann.
Neutron Unbound Systems, East Lansing, July 14, (2021).

92. Machine learning techniques for analyzing multi-neutron decay measurements.
Thomas Redpath, Megan Brayton, Darrius Sykes, and the MoNA Collaboration
Bull. Am. Phys. Soc. QM.00009, Diversity Workshop, DNP2021 Fall Meeting of the APS Division of Nuclear Physics, Boston, MA (2021).

93. From Engineering to Physics and Back: A Mixture of Two Worlds.
Grace M Townley, Paul L Gueye, Thomas Baumann, Yannick Gueye, Casey Hulbert, and the MoNA Collaboration
Bull. Am. Phys. Soc. PM.00001, Diversity Workshop, DNP2021 Fall Meeting of the APS Division of Nuclear Physics, Boston, MA (2021).

94. Preliminary investigations of a polarized target for the study of neutron unbound systems.
Georgia Votta, Paul L Gueye, and the MoNA Collaboration
Bull. Am. Phys. Soc. KF.00005, Diversity Workshop, DNP2021 Fall Meeting of the APS Division of Nuclear Physics, Boston, MA (2021).

95. Preliminary Simulations of the Multi-layer Active target for MoNA Experiments (MAME).
Nicholas Mendez, Thomas Redpath, Phuonganh Pham, Paul L Gueye, and the MoNA Collaboration
Bull. Am. Phys. Soc. FJ.00009, Diversity Workshop, DNP2021 Fall Meeting of the APS Division of Nuclear Physics, Boston, MA (2021).

96. Search for ^{15}Be+3n.
Anthony N. Kuchera, Rida Shahid, Aidan J. Edmondson, Jinpai Zhao, Nathan H. Frank, and Oscar Peterson-Veatch
Bull. Am. Phys. Soc. EF.00005, DNP2021 Fall Meeting of the APS Division of Nuclear Physics, Boston, MA (2021).

97. Designing a neutron detector with improved position resolution for the MoNA Collaboration.
Thomas Baumann
Bull. Am. Phys. Soc. DJ.00004, DNP2021 Fall Meeting of the APS Division of Nuclear Physics, Boston, MA (2021).

98. Performance of a charged particle detector system to study unbound systems at FRIB.
Nathan H. Frank, Thomas Baumann, Paul A. DeYoung, Paul L. Gueye, Anthony N. Kuchera, Belen Monteagudo, Geogia Votta, Henry Webb, and Xinyi Wang
Bull. Am. Phys. Soc. EJ.00005, DNP2021 Fall Meeting of the APS Division of Nuclear Physics, Boston, MA (2021).

99. Fast neutron scattering and multiple-neutron detection in MoNA.
W.F. Rogers, A. Munroe, J. Hallett, and the MoNA Collaboration
Bull. Am. Phys. Soc. QF.00004, DNP2021 Fall Meeting of the APS Division of Nuclear Physics, Boston, MA (2021).

100. A search for the ^{12}Be Isomeric State.
Xinyi Wang, Paul L. Gueye, Thomas Baumann, Paul A. DeYoung, Nathan H. Frank, and Anthony N. Kuchera
Bull. Am. Phys. Soc. FF.00005, DNP2021 Fall Meeting of the APS Division of Nuclear Physics, Boston, MA (2021).

101. Neutron-unbound excited states in ^{31}Ne.
Dayah N Chrisman, Anthony N Kuchera, Thomas Baumann, B A Brown, Nathan H Frank, Paul L Gueye, Belen Monteagudo, and Jeffrey A Tostevin
Bull. Am. Phys. Soc. MF.00003, DNP2021 Fall Meeting of the APS Division of Nuclear Physics, Boston, MA (2021).

102. Investigation of the reaction mechanism in the neutron emission from unbound excited states in 27F by the MoNA Collaboration.
Paul L Gueye, Thomas Redpath, Thomas Baumann. Alaura Cunningham, Belen Monteagudo, and Jared Bloch
Bull. Am. Phys. Soc. MF.00005, DNP2021 Fall Meeting of the APS Division of Nuclear Physics, Boston, MA (2021).

103. Shell spectroscopy sensitivity via the ground state population of ^{26}O from halo nuclei in proton removal reactions.
Paul L Gueye, Thomas Baumann, Thomas Redpath, Belen Monteagudo, Alaura Cunningham, Kevin Fossez, Nathan H Frank, Jimmy Rotureau, and Anthony N Kuchera
Bull. Am. Phys. Soc. MF.00001, DNP2021 Fall Meeting of the APS Division of Nuclear Physics, Boston, MA (2021).

104. 2021 Physicists Inspiring the Next Generation: Exploring the Nuclear Matter – Pre-College Students Perspectives.
Paul L Gueye, Paul L Gueye, Thomas Baumann, and Casey Hulbert

Bull. Am. Phys. Soc. PM.00004, DNP2021 Fall Meeting of the APS Division of Nuclear Physics, Boston, MA (2021).

105. Preliminary Simulations of the Multi-layer Active target for MoNA Experiments (MAME).
Nicholas Mendez, Thomas Redpath, Phuonganh Pham, and Paul L Gueye
Bull. Am. Phys. Soc. FJ.00009, DNP2021 Fall Meeting of the APS Division of Nuclear Physics, Boston, MA (2021).

106. Preliminary Performance Studies of the MoNA-Sweeper setup in S2 at FRIB.
Andrew Wantz, Paul L Gueye, Thomas Baumann, and Belen Monteagudo
Bull. Am. Phys. Soc. KJ.00008, DNP2021 Fall Meeting of the APS Division of Nuclear Physics, Boston, MA (2021).

107. From Engineering to Physics and Back: A Mixture of Two Worlds.
Grace M Townley, Paul L Gueye, Thomas Baumann, Yannick Gueye, and Casey Hulbert
Bull. Am. Phys. Soc. KJ.00008, DNP2021 Fall Meeting of the APS Division of Nuclear Physics, Boston, MA (2021).

108. Nuclear science at Virginia State University: building connections to FRIB Science
Thomas Redpath, Megan Brayton, Darrius Sykes, Jeffrey Walters, Clifton Kpadehyea, Paul Guèye, Grace Ndip, and The MoNA Collaboration
HBCU-UP PI's Meeting, February (2022)

109. A Mentoring Program for Community Building.
Nathan H. Frank, Oscar O. Peterson-Veatch, and Megan Anderson
Bull. Am. Phys. Soc. B13.00004, APR22 meeting of the American Physical Society, New York, April 9-12, (2022).

110. Simulations of the Multi-Layer Active target for MoNA Experiments (MAME) with Garfield++
Nicholas Mendez
Poster, Nuclear Structure 2022, Berkeley, CA, June (2022).

111. Neutron-unbound states in ^{34,35}Al* and ^{34}Mg*.
Belen Monteagudo Godoy, Anthony N. Kuchera, Nathan H. Frank, Dayah N. Chrisman, and the MoNA Collaboration,
DG.00001, DNP2022 Fall meeting of the Division of Nuclear Physics, New Orleans, Oct. 27-30, (2022).

112. A Search for the ^{12}Be Isomeric State,
Xinyi Wang, Paul L. Gueye, Paul A. DeYoung, Thomas Baumann, Nathan H. Frank, Anthony N. Frank, Belen Monteagudo Godoy, Thomas Redpath, and the MoNA Collaboration,
DG.00001, DNP2022 Fall meeting of the Division of Nuclear Physics, New Orleans, Oct. 27-30, (2022).

113. Neutron-unbound states in 32Na.
Anthony N. Kuchera, Dayah N. Chrisman, Nathan H. Frank, Belen Monteagudo Godoy, and the MoNA Collaboration,
EG.00002, DNP2022 Fall meeting of the Division of Nuclear Physics, New Orleans, Oct. 27-30, (2022).

114. Population of ^{33}Mg* Neutron-Unbound States from Reactions on ^{36}Si and ^{34}Al.
Nathan H. Frank, Anthony N. Kuchera, Belen Monteagudo Godoy, Dayah N. Chrisman, and the MoNA Collaboration,
GG.00003, DNP2022 Fall meeting of the Division of Nuclear Physics, New Orleans, Oct. 27-30, (2022).

115. Simulations of the Multi-layer Active target for MoNA Experiments (MAME) with Garfield++
Nicholas Mendez, Thomas H. Redpath, Paul L. Gueye, Phuonganh Pham, and the MoNA Collaboration,
EI.00007, DNP2022 Fall meeting of the Division of Nuclear Physics, New Orleans, Oct. 27-30, (2022).

116. Machine Learning and Particle Identification for Neutron-Unbound Studies at FRIB.
Andrew Wantz, Thomas Redpath, Belen Monteagudo Godoy, Paul L. Gueye, and Thomas Baumann,
LG.00006, DNP2022 Fall meeting of the Division of Nuclear Physics, New Orleans, Oct. 27-30, (2022).

117. The 2022 Physicists Inspiring the Next Generation: Exploring the Nuclear Matter.
Paul L. Gueye, Thomas J Baumann, Yannick Gueye, Joshua Marshall, Dominic L. Davis, Eric Pierce, Jayla Edwards, Donovan Flagg, Casey Hulbert, Tieler Graham, Astro Bren, Rocio Di Maria, Trysten Harris, Drake Hollins, Jacob Ryabinky, Keven Brooks-II, Bradley Thomas, Skyler Hamlin, Guhyun Jeong, Addison Hannah, Thomas Hays, Phillip Carington, Bryan Robles, Han Truong, Brenden Lamp, and Nolan Tusing,
GM.00007, DNP2022 Fall meeting of the Division of Nuclear Physics, New Orleans, Oct. 27-30, (2022).

118. Diversifying the Nuclear Physics Workforce: A Dream Or A Reality?
Geraldine L. Cochran, Felecia Commodore, Abdalla Darwish, Paul L. Gueye, Casey Hulbert, Filomena Nunes, Hendrik Schatz, Gregory Severin, Bradley M. Sherrill, Artemis Spyrou, Steve Thomas, and Remco G. Zegers,
GM.00005, DNP2022 Fall meeting of the Division of Nuclear Physics, New Orleans, Oct. 27-30, (2022).

119. Next Generation Fast Neutron Detector With High Position Resolution.
Thomas Baumann, Adriana Banu, James A. Brown, Paul DeYoung, Nathan Frank, Paul Gueye, Anthony Kuchera, Belen Monteagudo Godoy, Thomas Redpath, and Warren F. Rogers,
abstract 84, 26th International Conference on the Application of Accelerators in Research & Industry and 53rd Symposium of Northeastern Accelerator Personnel, Denton, TX, October 30 to November 3, (2022).

120. Status of the Multi-layer Active target for MoNA Experiment (MAME)
Iulia Maria Harca, Paul L Gueye, Nicholas Mendez, Thomas Redpath, Marco Cortesi, Thomas J Baumann, and Hannah Erington
Bull. Am. Phys. Soc. Poster Q16.00001, APR23 meeting of the American Physical Society, Minneapolis, Minnesota, Apr 15-18 (2023).

7.3 Standard Talks and Posters at Conferences by Undergraduates

1. Accurate energy calibrations from cosmic ray measurements
A. DeLine, J. Finck, A. Spyrou, M. Thoennessen, and P. DeYoung
Poster presented at the 2008 April APS meeting, Bull. Am. Phys. Soc. 53, No. 5, 219, S18.00005 (2008)

2. Nuclear astrophysics outreach program now employs researcher's equipment for enhancement
Amy DeLine, Zach Constan, and Joseph Finck
Winter Meeting of the AAPT, Chicago, IL (2009)

3. Undergraduate experiences in cutting-edge research experiments
A. Haagsma, K. Rethman, MoNA Collaboration
Bull. Am. Phys. Soc. 55, No. 1, 97, poster G11.00003 (2010)

4. Spectroscopy of ^{13}Li
E. M. Lunderberg, C. C. Hall, P. A. DeYoung, M. Thoennessen, J. Snyder
Bull. Am. Phys. Soc. 56, No. 12, JF.00001 (2011)

5. Dual Phase TPC/TH-GEM based target to study unbound nuclei
Angel Christopher
2018 National Society of Black Physicists annual meeting, Columbus, OH, November 4-7 (2018)

6. Visualizing MoNA/LISA data to aid in developing an event classification library
Clifton Kpadehyea, Darrius Sykes, Megan Brayton, Thomas Redpath, and the MoNA Collaboration,
Bull. Am. Phys. Soc. Poster S17.00016, APR22 meeting of the American Physical Society, New York, April 9-12, (2022).

7. Deblurring decay energy spectrum from invariant mass measurement.
Pierre Nzabahimana, Thomas Redpath, Pawel Danielewtitleicz, Thomas Baumann, Pablo Giuliani, and Paul Gueye,
KH.00006, DNP2022 Fall meeting of the Division of Nuclear Physics, New Orleans, Oct. 27-30, (2022).

7.4 Seminars and Colloquia

1. MoNA: the Modular Neutron Array
Joseph E. Finck
Physics Department Seminar, Central Michigan University, Mount Pleasant, MI, October 25, 2001

2. Physics at the neutron dripline: The MoNA Project and the NSCL
Bryan Luther
Department of Physics Seminar, North Dakota State University, Fargo, ND, October 16, 2002

3. Giving students a taste of research
Bryan Luther
Department of Physics Seminar, North Dakota State University, Fargo, ND, October 16, 2002

4. The Coupled Cyclotron Facility and MoNA at the NSCL
   Thomas Baumann
   Triangle Universities Nuclear Laboratory Seminar, Durham, NC, November 21, 2002

5. MoNA: The Modular Neutron Array
   Bryan Luther
   Centennial Scholars Program, Moorhead, MN, February 11, 2003

6. Development of neutron detectors
   Ruth Howes
   Seminar at Mt. San Antonio College, Walnut, CA, March 28, 2003

7. MoNA: detector development as undergraduate research
   Ruth Howes
   Workshop on Detector Development, Bloomington, IN, May 30, 2003

8. MoNA and physics at the nuclear dripline
   Ruth Howes
   Colloquium at Marquette University, Milwaukee, WI, January 29, 2004

9. Status of the Modular Neutron Array, new opportunities near the neutron dripline
   James A. Brown
   Ball State University, Muncie, IN, November 11, 2004

10. Where the sidewalk ends: MoNA and the neutron dripline
    Bryan Luther
    Physics Department Colloquium, Carleton College, Northfield, MN, March 10, 2005

11. Exploring the neutron dripline with MoNA
    Michael Thoennessen
    Physics Department Colloquium, Argonne National Laboratory, Argonne, IL, February 3, 2006

12. Nuclear structure studies with the Modular Neutron Array
    James A. Brown
    Duke University, Triangle Universities Nuclear Structure Laboratory, Durham, NC, March 2, 2006

13. The Modular Neutron Array & the MoNA collaboration
    Thomas Baumann
    Physics Department Seminar, Central Michigan University, Mount Pleasant, MI, March 30, 2006

14. Selective population and neutron decay of the first excited state of semi-magic ^{23}O
    A. Schiller
    Nuclear Physics Seminar, Argonne National Laboratory, Argonne, IL, December 18, 2006

15. Physics with the Modular Neutron Array
    Joseph E. Finck
    Physics Department Seminar, Central Michigan University, Mount Pleasant, MI, January 11, 2007

16. Exploring the edge of the nuclear universe
    Michael Thoennessen
    Physics Department Colloquium, Smith College, Northampton, MA, February 17, 2007

17. Nuclear physics near the dripline: Present and future of MoNA
    Nathan Frank
    Physics Department Seminar, Central Michigan University, Mount Pleasant, MI, March 23, 2007

18. Exploring the edge of the nuclear universe
    Michael Thoennessen
    Seminar, Department of Biological & Physical Sciences, South Carolina State University, Orangeburg, SC, February 26, 2008

19. Studying exotic nuclei with the Modular Neutron Array (MoNA)
Artemis Spyrou
Seminar, Physics Department, Indiana University South Bend, November 13, 2008

20. Explorations of the driplines at the NSCL
Michael Thoennessen
College 3 Seminar, Institute Laue Langevin, Grenoble, France, November 21, 2008

21. Studying exotic nuclei with the Modular Neutron Array (MoNA)
Artemis Spyrou
Seminar, Department of Physics, Grand Valley State University, November 2, 2009

22. Discovery of new isotopes at and beyond the neutron dripline
Michael Thoennessen
Kernphysikalisches Kolloquium, Institut für Kernphysik, Universität zu Köln, Germany, February 3, 2010

23. Traveling beyond the neutron dripline with MoNA
A. Spyrou
Seminar given at Oakridge National Lab, June 2010

24. Physics at the neutron dripline
Sharon Stephenson
Physics Department Colloquium, Franklin and Marshall College, Lancaster, PA, October 13, 2011

25. Construction, testing, and installation of the Large Multi-Institutional Scintillator Array (LISA)
D. A. Meyer
University of Kentucky, Lexington, KY, 21 April 2011

26. Exploring the edge of the nuclear universe
Michael Thoennessen
Seminar, Dept. of Physics and Astronomy, Indiana University South Bend, South Bend, IN, February 10, 2011

27. Exploring the edge of the nuclear universe
Michael Thoennessen
Muller Prize Lecture, Ohio Wesleyan University, Delaware, OH, Feb. 22, 2011

28. Expanding the nuclear horizon
Michael Thoennessen
Department of Physics & Astronomy Colloquium, Stony Brook University, Stony Brook, NY, March 1, 2011

29. Expanding the nuclear horizon
Michael Thoennessen
iThemba Laboratory Colloquium, Stellenbosch, South Africa, March 8, 2011

30. Physics at the neutron dripline
Sharon Stephenson
Franklin and Marshall College, October 13, 2011

31. Undergraduate research in nuclear physics
Nathan Frank
Indiana University South Bend, South Bend, IN, March 8, 2012

32. MoNA-LISA and the rare, shortlived world of exotic nuclei
Sharon Stephenson
SUNY-Geneseo, April 12, 2012

33. Going beyond the neutron dripline: Recent measurements of two-neutron unbound nuclei
Zachary Kohley
Webinar for the Nuclear Science and Security Consortium, October 2012

34. First observation of ground state di-neutron decay: ^{16}Be
A. Spyrou
Seminar given at NSCL, February 2012

35. Nuclear structure along the neutron drip line: recent results of MoNA
A. Spyrou
Seminar at Argonne National Lab, April 2012

36. Nuclear structure along the neutron dripline
A. Spyrou
Colloquium at Fermi Lab, September 2012

37. Research on unstable atomic nuclei with undergraduates
Nathan Frank
Celebration of Scholarship at Augustana College, February 18, 2013

38. Neutron-rich nuclear physics at Michigan State University
Jenna Smith
Seminar, Indiana University - South Bend, March 28, 2013

39. Measuring oxygen isotopes beyond the neutron dripline: Two-neutron emission and radioactivity
Zachary Kohley
Australian National University, Canberra, Australia, November 2013

40. Measuring oxygen isotopes beyond the neutron dripline: Two-neutron emission and radioactivity
Zachary Kohley
Central Michigan University, Mount Pleasant, MI, September 2013

41. Studying Atomic Nuclei with Undergraduates
Nathan Frank
Colloquium, Department of Physics, Hampton University, Hampton, VA, April 3, 2014

42. The MoNA collaboration and undergraduate education.
Paul A. DeYoung
2014 DNP/LRP Town Meeting on Education and Innovation, August 7, 2014.

43. Making Beautiful Physics with the Help of MoNA-LISA
Sharon Stephenson
Ithaca College April 28, 2015.

44. The unbound nuclei and the dineutron.
Bryan A. Luther
Concordia College, April 10, 2015.

45. Investigations near the neutron dripline.
James Brown
Ball State University, November 2015.

46. Sweeper/MoNA-LISA setup to the S800.
N. Frank.
Low Energy Community Meeting, University of Notre Dame, South Bend, IN, Aug. 10-13, 2016.

47. Neutron detection with MoNA for nuclear structure and reaction studies.
A. Kuchera
Argonne National Laboratory, Physics Division Seminar, May 22, 2017.

48. Nuclear Physics Fun at the Edge, Department of Physics.
Nathan Frank
Marquette University, Milwaukee, WI, November 9, 2017.

49. Sweeper/MoNA-LISA setup to the S800: Study of ^{37}Mg.
Nathan Frank
Low Energy Community Meeting, Argonne National Laboratory, Aug. 3-4, 2017.

50. Fast-neutron spectroscopy at FRIB: how well does simulation predict neutron scattering in plastic scintillator at FRIB energies? A critical test using direct single-neutron scattering observations.
W. Rogers
University of Notre Dame, Physics Department, October 1, 2018.

51. Study of Neutron-Decay of Exotic Nuclei using the MoNA-LISA Detector Arrays and Monte Carlo Simulation.
W. Rogers
Indiana University Purdue University Indianapolis (IUPUI), Physics, March 29, 2018.

52. Neutron Drip Line Studies with MoNA-LISA.
S. Stephenson
Rutgers University, May 6, 2019

53. Next Generation Neutron Detector
Thomas Baumann
NSCL Research Discussion, April 9, 2020

54. Towards neutron-unbound physics in the FRIB era.
Thomas Redpath
Central Michigan University seminar February 9, (2022)

55. Towards neutron-unbound physics in the FRIB era.
Thomas Redpath,
Virginia Union University colloquium, Richmond VA, February, 2022

56. MoNA-LISA: drip-oil painting with Leonardo da Vinci to drip-line with FRIB
Paul Guèye
City Polytechnic High School of Engineering, Architecture, and Technology
June 11, 2021.

7.5 Undergraduate Presentations: CEU Posters

CEU, 2002 DNP Fall Meeting, East Lansing, MI

1. Veto detectors for the micro-modular neutron array
Y. Lu, T. Baumann, M. Thoennessen, E. Tryggestad, M. Evanger, B. Luther, M. Rajabali, R. Turner
Bull. Am. Phys. Soc. 47, No. 6, 48 (2002)

2. First radioactive beam experiment with the Modular Neutron Array MoNA
M. Rajabali, M. Evanger, R. Turner, B. Luther, T. Baumann, Y. Lu, M. Thoennessen, E. Tryggestad
Bull. Am. Phys. Soc. 47, No. 6, 54 (2002)

3. Neutron testing of the micro-Modular Neutron Array
M. Evanger, M. Rajabali, R. Turner, B. Luther, T. Baumann, Y. Lu, M. Thoennessen, E. Tryggestad
Bull. Am. Phys. Soc. 47, No. 6, 55 (2002)

4. Cosmic ray testing of the micro-Modular Neutron Array
R. Turner, M. Evanger, M. Rajabali, B. Luther, T. Baumann, Y. Lu, M. Thoennessen, E. Tryggestad
Bull. Am. Phys. Soc. 47, No. 6, 55 (2002)

5. The MoNA project
P. J. VanWylen, J. P. Bychowski, P. A. DeYoung, G. F. Peaslee, The MoNA Consortium
Bull. Am. Phys. Soc. 47, No. 6, 60 (2002)

CEU, 2003 DNP Fall Meeting, Tucson, AZ

1. Calibration of the Modular Neutron Array (MoNA)
S. Clark, N. Walker, W. Rogers, T. Baumann, M. Thoennessen, A. Stolz, W. Peters
Bull. Am. Phys. Soc. 48, No. 8, 51 (2003)

2. High voltage control of the Modular Neutron Array
S. Marley, T. Baumann, N. Frank, E. Johnson, W. Peters, M. Thoennessen, B. Luther
Bull. Am. Phys. Soc. 48, No. 8, 59 (2003)

3. Cosmic rays in MoNA
E. Johnson, M. Thoennessen, T. Baumann, W. Peters, S. Marley, B. Luther
Bull. Am. Phys. Soc. 48, No. 8, 61 (2003)

CEU, 2004 DNP Fall Meeting, Chicago, IL

1. Determination of position resolution for the Modular Neutron Array using cosmic rays
   J. Miller, M. Kleber, B. Luther, MoNA Collaboration
   Bull. Am. Phys. Soc. 49, No. 6, 60 (2004)

2. MoNA and initial measurements with ^{7}He resonance
   T. Pike, R. Pepin, MoNA Collaboration
   Bull. Am. Phys. Soc. 49, No. 6, 62 (2004)

3. Cosmic muon tracking with MoNA
   K. Watters, L. Elliott, M. Strongman, W. Rogers
   Bull. Am. Phys. Soc. 49, No. 6, 64 (2004)

4. Calibration of the Modular Neutron Array
   R. Pepin, T. Pike, MoNA Collaboration
   Bull. Am. Phys. Soc. 49, No. 6, 67 (2004)

CEU, 2005 DNP Fall Meeting, Maui, HI

1. Tracking single and multiple events in MoNA
   A. Stump, A. Ratkiewicz, MoNA Collaboration
   Bull. Am. Phys. Soc. 50, No. 6, 143 (2005)

2. MoNA calibration and neutron tracking
   S. Mosby, E. Mosby, W. F. Rogers, MoNA Collaboration
   Bull. Am. Phys. Soc. 50, No. 6, 143 (2005)

CEU, 2006 DNP Fall Meeting, Nashville, TN

1. An automated relative time calibration for MoNA
   D. Albertson, MoNA Collaboration
   Bull. Am. Phys. Soc. 51, No. 6, 48 (2006)

2. Analysis of kinematics and decay energy in the breakup of ^{7}He
   D. Denby, P. DeYoung, G. Peaslee, MoNA Collaboration
   Bull. Am. Phys. Soc. 51, No. 6, 52 (2006)

3. Calibration of the thick and thin scintillators for the NSCL/FSU Sweeper magnet system
   A. Hayes, MoNA Collaboration
   Bull. Am. Phys. Soc. 51, No. 6, 54 (2006)

4. Cosmic muon flux variations using the Modular Neutron Array
   E. Mosby, S. Mosby, J. Gillette, M. Reese, W. F. Rogers, MoNA Collaboration
   Bull. Am. Phys. Soc. 51, No.‘6, 58 (2006)

5. Neutron multiplicity discrimination in MoNA
   S. Mosby, E. Mosby, W. F. Rogers, MoNA Collaboration
   Bull. Am. Phys. Soc. 51, No. 6, 58 (2006)

CEU, 2007 DNP Fall Meeting, Newport News, VA

1. Search for upward cosmic rays
   E. White, A. Spyrou, M. Thoennessen, T. Yoast-Hull, MoNA Collaboration
   Bull. Am. Phys. Soc. 52, No. 9, 68 (2007)

2. Efficiency and multi-hit capability improvements of MoNA
   T. Yoast-Hull, A. Spyrou, M. Thoennessen, E. White, MoNA Collaboration
   Bull. Am. Phys. Soc. 52, No. 9, 69 (2007)

CEU, 2008 DNP Fall Meeting, Oakland, CA

1. Geant4 simulation of MoNA
   A. Fritsch, M. Heim, T. Baumann, S. Mosby, A. Spyrou
   Bull. Am. Phys. Soc. 53, No. 12, DA.00028 (2008)

2. Investigation of neutron scattering in the Modular Neutron Array (MoNA)
   M. Gardener, W. F. Rogers
   Bull. Am. Phys. Soc. 53, No. 12, DA.00030 (2008)

3. Experimental observation of decay energy of ^{12,13}Li
   C. Hall, P.A. DeYoung, S. Mosby, A. Spyrou, M. Thoennessen
   Bull. Am. Phys. Soc. 53, No. 12, DA.00037 (2008)

CEU, 2009 DNP Fall Meeting, Waikoloa, HI

1. Spectroscopy of ^{12}Li
   E. Lunderberg, C. Hall, P. DeYoung, A. Spyrou, M. Thoennessen, MoNA Collaboration
   CEU Poster GB0.00070, Bull. Am. Phys. Soc. 54, No. 10, 150 (2009) Division of Nuclear Physics Fall Meeting, Waikoloa, Hawaii (2009)

2. Observation of neutron-unbound resonant stated in ^{23}O and ^{28}Ne
   J. Novak, S. Quinn, M. Strongman, S. Mosby, A. Spyrou, T. Baumann, M. Thoennessen, and the MoNA Collaboration
   CEU Poster GB.00091, Bull. Am. Phys. Soc. 54, No. 10, 154 (2009)

3. Non-resonant neutron emission of excited neutron-rich nuclei
   S. Quinn, J. Novak, M. Strongman, S. Mosby, A. Spyrou, T. Baumann, M. Thoennessen, and the MoNA Collaboration
   CEU Poster GB.00100, Bull. Am. Phys. Soc. 54, No. 10, 155 (2009)

4. Accurate position calibration for charged fragments
   A. Russell, J. E. Finck, A. Spyrou, M. Thoennessen, and the MoNA Collaboration
   CEU Poster GB.00103, Bull. Am. Phys. Soc. 54, No. 10, 156 (2009)

CEU, 2010 DNP Fall Meeting, Santa Fe, NM

1. Testing the Large-area multi-Institutional Scintillator Array (LISA) neutron detector
   T. B. Nagi, K. M. Rethman, K. A. Purtell, A. J. Haagsama, C. DeRoo, M. Jacobson, S. Kuhn, A. R. Peters, M. Ndong, S. A.Stewart, Z. Torstrick, R. Anthony, H. Chen, A. Howe, N. S. Badger, M. D. Miller, B. J. Foster, L. C. Rice, B. C. Vest, A. B. Aulie, A. Grovom, L. Elliott, and P. Kasavan
   CEU Poster EA.00078, Division of Nuclear Physics Fall Meeting, Santa Fe, NM (2010)

2. Performance comparison of MoNA and LISA neutron detectors
   Kimberly Purtell, Kaitlynne Rethman, Autumn Haagsma, Joseph Finck, Jenna Smith, Jesse Snyder
   CEU Poster EA.00090, Division of Nuclear Physics Fall Meeting, Santa Fe, NM (2010)

3. Construction of the Large-area multi-Institutional Scintillator Array (LISA) neutron detector
   Kaitlynne Rethman, Kimberly Purtell, Autumn Haagsma, Casey DeRoo, Megan Jacobson, Steve Kuhn, Alexander Peters, Tim Nagi, Sam Stewart, Zack Torstrick, Mathieu Ndong, Rob Anthony, Hengzhi Chen, Alex Howe, Nicholas Badger, Matthew Miller, Brad Vest, Ben Foster, Logan Rice, Alegra Aulie, Amanda Grovom, Philip Kasavan, Lewis Elliott
   CEU Poster EA.00093, Division of Nuclear Physics Fall Meeting, Santa Fe, NM (2010)

4. Search for angular anisotropies in neutron emissions of fragmentation reactions with secondary beams
   Sam Novario, Greg Christian, Jenna Smith, Michael Thoennessen
   CEU Poster EA.00081, Division of Nuclear Physics Fall Meeting, Santa Fe, NM (2010)

5. Tagging the decay of neutron unbound states near the dripline
   Alissa Wersal, Greg Christian, Michael Thoennessen, Artemis Spyrou
   CEU Poster EA.00126, Division of Nuclear Physics Fall Meeting, Santa Fe, NM (2010)

6. Analysis of an experiment on neutron-rich isotopes
   S. Ash, M. Warren, N. Frank, G. Christian, A. Gade, A. Spyrou, M. Thoennessen, T. Baumann, G. F. Grinyer, D. Weisshaar, P. A. DeYoung
   CEU Poster EA.00005, Division of Nuclear Physics Fall Meeting, Santa Fe, NM (2010)

7. MoNA and two-neutron decay analysis
   Amanda Grovom, Alegra Aulie, Warren F. Rogers
   CEU Poster EA.00007, Division of Nuclear Physics Fall Meeting, Santa Fe, NM (2010)

CEU, 2011 DNP Fall Meeting, East Lansing, MI

1. Modeling neutron events in MoNA-LISA using MCNPX
   Margaret Kendra Elliston, Alexander Peters, Kristen Stryker, Sharon Stephenson, MoNA Collaboration
   CEU Poster EA.00039, Division of Nuclear Physics Fall Meeting, East Lansing, MI (2011)

2. Calibration of the MoNA and LISA arrays for the LISA commissioning experiment
   A. Grovom, J. Kwiatkowski, W. F. Rogers, MoNA Collaboration
   CEU Poster EA.00058, Division of Nuclear Physics Fall Meeting, East Lansing, MI (2011)

3. Calibration of the sweeper chamber charged-particle detectors for the LISA commissioning experiment
   J. Kwiatkowski, A. Grovom, W. Rogers, Westmont College, MoNA Collaboration
   CEU Poster EA.00073, Division of Nuclear Physics Fall Meeting, East Lansing, MI (2011)

4. Optical attenuation in MoNA and LISA detector elements
   Logan Rice, Jonathan Wong, MoNA Collaboration
   CEU Poster EA.00112, Division of Nuclear Physics Fall Meeting, East Lansing, MI (2011)

5. Testing and installation of a high efficiency CsI scintillator array
   Natalie Viscariello, Stuart Casarotto, Nathan Frank, Jenna Smith, Michael Thoennessen
   CEU Poster EA.00135, Division of Nuclear Physics Fall Meeting, East Lansing, MI (2011)

CEU, 2012 DNP Fall Meeting, Newport Beach, CA

1. Simulating neutron interactions in the MoNA-LISA/Sweeper setup with Geant4
   Magdalene MacArthur
   CEU Poster EA.00054, Division of Nuclear Physics Fall Meeting, Newport Beach, CA (2012)

2. Analysis of LISA commissioning run data for study of ^{24}O excited state decay energies
   N. Taylor, S. Garrett, A. Barker and W. F. Rogers
   CEU Poster EA.00060, Division of Nuclear Physics Fall Meeting, Newport Beach, CA (2012)

3. Calibration of charged-particle detectors for the LISA commissioning experiment
   S. Garrett, N. Taylor, A. Barker and W. Rogers
   CEU Poster EA.00059, Division of Nuclear Physics Fall Meeting, Newport Beach, CA (2012)

4. Active target simulation
   Nathan Smith, Peter Draznik and Nathan Frank
   CEU Poster EA.00003, Division of Nuclear Physics Fall Meeting, Newport Beach, CA (2012)

5. Exploration of three-body decay using jacobian coordinates
   Mark Hoffmann, Kyle Williams and Nathan Frank
   CEU Poster EA.00002, Division of Nuclear Physics Fall Meeting, Newport Beach, CA (2012)

6. Composition of the ^{24}O ground state wave function
   R. A. Scotten, E. Traynor, P. A. DeYoung, N. T. Islam and R. A. Haring-Kaye
   CEU Poster EA.00066, Division of Nuclear Physics Fall Meeting, Newport Beach, CA (2012)

7. Preparation for MoNA/LISA VANDLE $^{56}Ni(d,n)$ experiment at the NSCL
   Z. J. Bergstrom, R. L. Kozub W. A. Peters, J. A. Cizewski, M. E. Howard, D.W. Bardayan, R. Ikeyama S.V. Paulauskas, M. Madurga, R. Grzywacz, P. A. DeYoung, T. Baumann, J. Smith and M. Thoennessen
   CEU Poster EA.00071, Division of Nuclear Physics Fall Meeting, Newport Beach, CA (2012)

CEU, 2013 DNP Fall Meeting, Newport News, VA

1. Precise timing calibration for MoNA and LISA detectors
   Sierra Garrett , Alyson Barker , Nathaniel Taylor , Warren F. Rogers
   CEU Poster EA.00062, Division of Nuclear Physics Fall Meeting, Newport News, VA (2013)

2. Isotope separation and decay energy calculation for LISA commissioning experiment
   Nathaniel Taylor , Alyson Barker , Sierra Garrett , Warren F. Rogers
   CEU Poster EA.00063, Division of Nuclear Physics Fall Meeting, Newport Beach, CA (2013)

3. Commissioning a hodoscope detector
   Andrew Lulis, Abdul Merhi, Nathan Frank, Daniel Bazin, Jenna Smith, Michael Thoennessen
   CEU Poster EA.00072, Division of Nuclear Physics Fall Meeting, Newport News, VA, October, 2013

4. Segmented target design
   Abdul Rahman Merhi, Nathan Frank, Paul Gueye, Michael Thoennessen
   CEU Poster EA.00074, Division of Nuclear Physics Fall Meeting, Newport News, VA, October, 2013

5. Converting VANDLE data into ROOT for merging with other systems
   Z.J. Bergstrom, R.L. Kozub, W.A. Peters, R. Ikeyama, S.V. Paulauskas, S. Ahn, RIBENS-, MoNA/LISA-, VANDLE-Collaborations
   CEU Poster EA.00080, Division of Nuclear Physics Fall Meeting, Newport News, VA, October, 2013

CEU, 2014 DNP Fall Meeting, Waikoloa, HI

1. Detector calibrations for fragmentations reactions with relativistic heavy ions at the NSCL
   Heather Garland, Sharon Stephenson, Michelle Mosby
   CEU Poster GB.00042, Division of Nuclear Physics Fall Meeting, Waikoloa, HI October, 2014

2. Unbound Resonances in Light Nuclei
   Elizabeth Havens, Joseph Finck, Paul Gueye, Michael Thoennessen
   CEU Poster GB.00041, Division of Nuclear Physics Fall Meeting, Waikoloa, HI October, 2014

3. Decay energies for ^{24}O → ^{23}O + n using MoNA-LISA-Sweeper detector systems and Monte Carlo simulations
   Sierra Garrett, Alyson Barker, Rachel Parkhurst, Warren Rogers, Anthony Kuchera
   CEU Poster GB.00043, Division of Nuclear Physics Fall Meeting, Waikoloa, HI October, 2014

CEU, 2015 DNP Fall Meeting, Sante Fe, NM

1. Production of Unbound Resonance in ^{23}O.
   J.J. Brett*, P. DeYoung, A. Rabeh*, M. Tuttle-timm*, N. Frank, M. Jones, M. Thoennessen, and the MoNA Collaboration
   CEU poster EA.00098, 2015 Fall Meeting of the APS Division of Nuclear Physics, Santa Fe, NM (2015).

2. Population of ^{13}Be with a Nucleon-Exchange Reaction.
   B. Marks*, P. DeYoung, J. Smith, M. Jones, M. Thoennessen, and the MoNA Collaboration.
   CEU poster EA.00104, 2015 Fall Meeting of the APS Division of Nuclear Physics, Santa Fe, NM (2015).

3. Unbound Resonance of ^{26}F.
   A. Rabeh*,M. Tuttle-Timm*, N. Frank, J.J. Brett*, P. DeYoug, M. Jones, M. Thoennessen, and the MoNA Collaboration
   CEU poster EA.00108, 2015 Fall Meeting of the APS Division of Nuclear Physics, Santa Fe, NM (2015).

4. Neutron unbound resonances cataloged by isotope and invariant mass measurements for nuclei Z=1-12.
   Elizabeth Havens, Joseph Finck, Paul Gueye, Michael Thoennessen, and the MoNA Collaboration.
   CEU poster EA.00102, 2015 Fall Meeting of the APS Division of Nuclear Physics, Santa Fe, NM (2015).

5. Calibrations for studies of neutron-rich precursor fragments.
   Maria Mazza, Rachel Parkhurst, Samuel Wilensky, Michelle Mosby, Sharon Stephenson, Warren Rogers,
   CEU poster EA.00105, 2015 Fall Meeting of the APS Division of Nuclear Physics, Santa Fe, NM (2015).

CEU 2016 DNP Fall meeting, Vancouver BC, Canada

1. Neutron multiplicity distributions for neutron-rich projectile fragments at the NSCL
   Maria Mazza, Peter Christ, and Sharon Stephenson.
   CEU poster EA.00115, 2016 Fall Meeting of the APS Division of Nuclear Physics, Vancouver BC, Canada (2016).

CEU 2017 DNP Fall meeting, Pittsburg, PA

1. Neutron Radioactivity in ^{26}O and Lifetime Analysis of Neutron-Rich Isotopes.
   C. Persch*, P. A. DeYoung, N. Frank, P. Gueye, A. Kuchera, T. Redpath, and the MoNA Collaboration,
   CEU Poster EA.00169 Fall Meeting of the APS Division of Nuclear Physics, Pittsburgh, PA (2017).

2. First Observation of Three-Neutron Sequential Emission from ^{25}O.
   C. Sword*, J. Brett*, P. A. DeYoung, N. Frank, H. Karrick*, A. N. Kuchers*, and the MoNA Collaboration,
   CEU Poster EA.00170 Fall Meeting of the APS Division of Nuclear Physics, Pittsburgh, PA (2017).

3. Sequential Decay of ^{26}F.
H. Karrick*, N. Frank, A. Kuchera, C. Sword*, J. Brett*, P. DeYoung, M. Thoennessen, and the MoNA Collaboration, C. Sword*, J. Brett*, P. A. DeYoung, N. Frank, H. Karrick*, A. N. Kuchers*, and the MoNA Collaboration,
CEU Postert EA.00167 Fall Meeting of the APS Division of Nuclear Physics, Pittsburgh, PA (2017).

4. Test of Monte Carlo Simulation for MoNA neutron detectors.
J.E. Boone*, A. Wantz*, W.F. Rogers, N. Frank, A.N. Kuchera, S. Mosby, M. Thoennessen
CEU Poster EA.00165 Fall Meeting of the APS Division of Nuclear Physics, Pittsburgh, PA (2017).

5. Determination of Partial Cross Sections in Single Nucleon Knockout Reactions
Tan Phan*, Anthony Kuchera, Daniel Bazin
CEU Poster EA.00155 Fall Meeting of the APS Division of Nuclear Physics, Pittsburgh, PA (2017).

6. Neutron Scattering in MoNA detector bars for Comparison with Simulation.
A. Wantz*, J.E. Boone*, W.F. Rogers, N. Frank, A.N. Kuchera, S. Mosby, M. Thoennessen,
CEU Poster EA.00171 Fall Meeting of the APS Division of Nuclear Physics, Pittsburgh, PA (2017).

CEU 2018, 5th Joint Meeting of the APS Division of Nuclear Physics and the Physical Society of Japan, Waikoloa, HI

1. Projectile-like fragment production studies: the role of magnetic rigidity.
Jonathan Hu, the MoNA Collaboration
CEU Poster HA.00081 5th Joint Meeting of the APS Division of Nuclear Physics and the Physical Society of Japan, Waikoloa, HI (2018).

2. Projectile-like Fragment production studies using coincident neutrons.
Edith Tea, the MoNA Collaboration
CEU Poster HA.00082 5th Joint Meeting of the APS Division of Nuclear Physics and the Physical Society of Japan, Waikoloa, HI (2018).

CEU 2019 Meeting of the APS Division of Nuclear Physics, Crystal City Virginia, Oct. 13–17.

1. Neutron Unbound States in the N=20 Island of Inversion.
Robbie Seaton-Todd, Anthony Kuchera, Nathan Frank, John Mcdonaugh, Paul Deyoung, Wiiliam Von Seeger, Thomas Baumann, Dayah Chrisman, Paul Gueye, and the MoNA Collaboration
CEU Poster HA.00019 Fall Meeting of the APS Division of Nuclear Physics, Crystal City, VA (2019).

2. Study of Neutron-rich Nuclides of Z = 13, 12.
John Mcdonaugh, Nathan Frank, Robbie Seaton-Todd, Anthony Kuchera, Paul Gueye, Paul DeYoung, Hope College, and the MoNA Collaboration
CEU Poster HA.00058 Fall Meeting of the APS Division of Nuclear Physics, Crystal City, VA (2019).

3. Characterizing a Charged Particle Detector Telescope
Georgia Votta, Nathan Frank, Thomas Baumann, James Brown, Paul DeYoung, and the MoNA Collaboration
CEU Poster HA.00059 Fall Meeting of the APS Division of Nuclear Physics, Crystal City, VA (2019).

CEU 2020 DNP Fall meeting, virtual

1. Angular distributions of dark scattered neutrons in plastic scintillators
Andrea Robinson, Caroline Capuano, Anthony Kuchera, Paul Gueye, and the MoNA Collaboration
CEU Poster HA.00006 Fall Meeting of the APS Division of Nuclear Physics, virtual (2020).

2. Behavior of Neutrons in Plastic Scintillators
Caroline Capuano, Andrea Robinson, Anthony Kuchera, Paul Gueye, and the MoNA Collaboration
CEU Poster JA.00006 Fall Meeting of the APS Division of Nuclear Physics, virtual (2020).

3. Development of a multi-neutron filter for use in the study of dripline nuclei
Jeremy Hallett, Andrea Munroe, Warren Rogers, and the MoNA Collaboration
CEU Poster PA.00011 Fall Meeting of the APS Division of Nuclear Physics, virtual (2020).

4. Exploring the Physics of Neutron-Unbound Nuclei Produced from Ne-28 and Ne-29 Fragment Beams
Alaura Cunningham and the MoNA Collaboration
CEU Poster QA.00002 Fall Meeting of the APS Division of Nuclear Physics, virtual (2020).

5. G4Beamline simulation for the study of Be isomers
   Yannick Gueye, Paul Gueye, Thomas Baumann, and the MoNA Collaboration
   CEU Poster NA.00003 Fall Meeting of the APS Division of Nuclear Physics, virtual (2020).

6. Investigation of a GEM based neutron detector for the MoNA Collaboration
   Maya Watts, Alder Fulton, Thomas Baumann, Thomas Redpath, (Michigan State University, National Superconducting Cyclotron Laboratory, Facility for Rare Isotope Beams) and the MoNA Collaboration
   CEU Poster HA.00003 Fall Meeting of the APS Division of Nuclear Physics, virtual (2020.

7. Measurement of Nuclear Isomer Gamma Emissions in Geant4
   Lauren Fisher, Andrea Bracamonte, Adam Fritsch, and Jim Brown
   CEU Poster JA.00013 Fall Meeting of the APS Division of Nuclear Physics, virtual (2020).

8. Non-Linear Behavior in Plastic Scintillator Neutron Detectors
   Andrea Munroe, Jeremy Hallett, Warren Rogers, and the MoNA Collaboration
   CEU Poster QA.00009 Fall Meeting of the APS Division of Nuclear Physics, virtual (2020).

9. Simulations of various GEM foil hole geometries using Garfield
   Pham Phuonganh and the MoNA Collaboration
   CEU Poster JA.00004 Fall Meeting of the APS Division of Nuclear Physics, virtual (2020).

10. Studying neutron-unbound states produced from a Na-30 beam
    Grant Bock and the MoNA Collaboration
    CEU Poster NA.00004 Fall Meeting of the APS Division of Nuclear Physics, virtual (2020).

11. Visualization and Interpolation of Field Mapping Data
    Anita Agasaveeran, Thomas Baumann, Paul Gueye, and the MoNA Collaboration
    CEU Poster JA.00003 Fall Meeting of the APS Division of Nuclear Physics, virtual (2020).

CEU 2021 DNP Fall meeting, virtual

1. Behavior of light and dark scattered neutrons in MoNA bars in comparison and simulation.
   Olivia Guarinello
   CEU Poster GA.00049 Fall Meeting of the APS Division of Nuclear Physics, Boston, MA (2021).

2. Behavior of dark scattered neutrons in plastic scintillators.
   Ari Maki
   CEU Poster HA.00049 Fall Meeting of the APS Division of Nuclear Physics, Boston, MA (2021).

3. Evaluation of Timing Scintillator Geometry.
   Hannah Erington, Thomas Bauman, and Paul Gueye
   CEU Poster HA.00046 Fall Meeting of the APS Division of Nuclear Physics, Boston, MA (2021).

4. Utilizing a Novel Neutron Filtering Technique to Analyze Multi-Neutron Datasets.
   Oscar Peterson-Veatch
   CEU Poster HA.00044 Fall Meeting of the APS Division of Nuclear Physics, Boston, MA (2021).

5. Analysis and simulation of ^{36}Si and ^{36}Al Reaction Products.
   Furman Doty
   CEU Poster HA.00047 Fall Meeting of the APS Division of Nuclear Physics, Boston, MA (2021).

6. A multi-layered approach to multi-neutron filtering.
   Andrea Munroe, Jeremy Hallett, Warren Rogers, and the MoNA Collaboration
   CEU Poster HA.00050 Fall Meeting of the APS Division of Nuclear Physics, Boston, MA (2021).

7. Cluster production in MoNA through charge exchange.
   Jeremy Hallett, Andrea Munroe, Warren Rogers, and the MoNA Collaboration
   CEU Poster HA.00048 Fall Meeting of the APS Division of Nuclear Physics, Boston, MA (2021).

8. Behavior of light and dark scattered neutrons in MoNA bars in comparison with simulation.
   Olivia Guarinello, Ari Maki, Anthony N Kuchera, and the MoNA Collaboration
   CEU Poster GA.00016 Fall Meeting of the APS Division of Nuclear Physics, Boston, MA (2021).

CEU, 2022 DNP Fall Meeting, New Orlean, LA

1. Reconstructing ^{10}Li Neutron-unbound States using a Compact Detector System
   Henry S. Webb, Nathan H. Frank, Xinyi Wang, Belen Monteagudo Godoy,
   CEU Poster HA.00002 Fall Meeting of the APS Division of Nuclear Physics (DNP2022), New Orleans, LA (2022).

2. Analysis of Neutron Scattering Interactions in Plastic Scintillators.
   Derick A Flores Madrid, Jenna L. Smith, Warren F. Rogers, and the MoNA Collaboration,
   CEU Poster HA.00090 Fall Meeting of the APS Division of Nuclear Physics (DNP2022), New Orleans, LA (2022).

3. LANL II Neutron Dark Scattering Analysis.
   Jenna L. Smith, Derick A. Flores, Warren F. Rogers, and the MoNA Collaboration,
   CEU Poster HA.00091 Fall Meeting of the APS Division of Nuclear Physics (DNP2022), New Orleans, LA (2022).

4. Machine learning algorithms for classifying multi-neutron decay measurements of neutron-unbound systems.
   Jaylen I. Rasberry, Thomas Redpath, Clifton D. Kpadehyea, and the MoNA Collaboration,
   CEU Poster HA.00002 Fall Meeting of the APS Division of Nuclear Physics (DNP2022), New Orleans, LA (2022).

5. Investigation of various material properties for a Cherenkov detector at the Facility for Rare Isotope Beams
   Anna Brandl, Justin Schmitz, Thomas Webb, Jacques Botsoa, Nicole Doumit, Jean- Philippe Blondeau, Paul Gu'eye, Esidor Ntsoenzok, Yamina Bennour, Conchi Ania
   CEU Poster HA.00010 Fall Meeting of the APS Division of Nuclear Physics (DNP2022), New Orleans, LA (2022).

6. Design concepts of a Cherenkov detector at the Facility for Rare Isotope Beams
   Sara Tatreau, Emily Holman, Phuonganh Pham, Conchi Ania, Paul Gu'eye, Esidor Ntsoenzok, Yamina Bennour
   CEU Poster HA.00009 Fall Meeting of the APS Division of Nuclear Physics (DNP2022), New Orleans, LA (2022).

7. Analysis of Neutron Dark Scattering from Plastic Scintillators
   Tahmid Awal, Kenneth Wang, and Anthony N Kuchera
   CEU Poster HA.00022 Fall Meeting of the APS Division of Nuclear Physics (DNP2022), New Orleans, LA (2022).

8. Testing Neutron Scattering on Plastic Scintillator Observables to Simulation.
   Kenneth Wang, Tahmid Awal, and Anthony N Kuchera
   CEU Poster HA.00056 Fall Meeting of the APS Division of Nuclear Physics (DNP2022), New Orleans, LA (2022).

7.6 Regional Undergraduate Presentations: Talks and Other Posters

1. The MoNA project
   U. Onwuemene and T. Grant
   Illinois Section of the AAPT Fall Meeting, Decatur, IL, October 18–19, 2002

2. The MoNA project
   M. R. Evanger and R. E. Turner
   Minnesota Area Association of Physics Teachers Fall Meeting, Morris, MN, October 25–26, 2002

3. Calibration of organic scintillator bars for the Modular Neutron Detector Array
   J. W. Longacre
   Indiana Section of the AAPT Spring Meeting, Bloomington, IN, April 25–26, 2003

4. Neutron detection by the Modular Neutron Array (MoNA)
   D. McCollum
   Indiana Section of the AAPT Spring Meeting, Bloomington, IN, April 25–26, 2003

5. Experimental developments along the neutron dripline
J. Robertson
Indiana Section of the AAPT Spring Meeting, Bloomington, IN, April 25–26, 2003

6. Tracking single and multiple neutron events in the Modular Neutron Array
A. Ratkiewicz
Society of Physics Students, Zone 9 Fall 2005 Meeting, Marquette University, Milwaukee WI, October 13–14, 2005

7. Tracking single and multiple neutron events in the Modular Neutron Array
A. Ratkiewicz
Joint Meeting of the 16th Annual Argonne Symposium for Undergraduates in Science, Engineering and Mathematics & the Central States Universities, incorporated (CSUI), November 4–5, 2005

8. Tracking single and multiple neutron events in the Modular Neutron Array
A. Ratkiewicz
20th National Conference on Undergraduate Research, Asheville, NC, April 5–8, 2006

9. Accurate energy calibrations from cosmic ray measurements
A. DeLine
Posters at the Capitol, Capitol Rotunda, Lansing, Michigan, April 16, 2008

10. Observation of a resonance state in ^{25}F
Alison R. Smith, Mark S. Kasperczyk, Nathan H. Frank
19th Annual Argonne Symposium for Undergraduates in Science, Engineering and Mathematics, Argonne National Laboratory, Argonne, Illinois, November 7, 2008

11. Observation of a resonance state in ^{25}F
Alison R. Smith, Mark S. Kasperczyk, Nathan H. Frank
Spring Meeting of the Illinois Section of the AAPT, Illinois Wesleyan University, Bloomington, Illinois, April 3–4, 2009

12. Observation of a resonance state in ^{26}F
Mark S. Kasperczyk, Alison R. Smith, Nathan H. Frank
Spring Meeting of the Illinois Section of the AAPT, Illinois Wesleyan University, Bloomington, Illinois, April 3–4, 2009

13. Assembly and testing of the Large Area Multi-Institutional Array: LISA
Mathieu Ndong, Samuel Stewart, and Zachary Torstrick
Notre Dame Science and Engineering Summer Research Symposium, August 6, 2010

14. Assembly and testing of scintillation neutron detectors for LISA
Alex R. Howe
Ohio Five Summer Science Research Symposium, Ohio Wesleyan University, Delaware, OH, July 23, 2010

15. Assembly and testing of LISA neutron detectors
Robert E. Anthony
Ohio Five Summer Science Research Symposium, Ohio Wesleyan University, Delaware, OH, July 23, 2010

16. Assembly and testing of the Large Area multi-Institutional Scintillator Array (LISA)
Zachary Torstrick, Samuel Stewart, Mathieu Ndong
25th National Conference on Undergraduate Research, Ithaca, NY, March 31–April 2, 2011

17. Analysis of neutron-rich isotopes
Natalie Viscariello
Celebration of Learning, Augustana College, Rock Island, IL, May 5, 2012

18. Testing and installation of a high-efficiency CsI scintillator array
Stuart Casarotto
Celebration of Learning, Augustana College, Rock Island, IL, May 5, 2012

19. Active target simulation
Nathan Smith
2012 Quadrennial Physics Congress, Orlando, FL, Nov. 8-10, 2012

20. Testing and installation of a high efficiency CsI scintillator array
Natalie Viscariello
2012 Quadrennial Physics Congress, Orlando, FL, Nov. 8-10, 2012

21. Active target simulation
Nathan Smith
Celebration of Learning, Augustana College, Rock Island, IL, Jan. 29, 2013

22. Testing and efficiency of a high efficiency CsI scintillator array
Natalie Viscariello
Sigma Xi Research Presentations, Augustana College, Rock Island, IL, Jan. 29, 2013

23. Exploration of three-body decay using Jacobian coordinates
Mark Hoffmann
Sigma Xi Research Presentations, Augustana College, Rock Island, IL, Jan. 29, 2013

24. Exploration of three-body decay using Jacobian coordinates
Mark Hoffmann and Kyle Williams
Sigma Xi Research Presentations, Augustana College, Rock Island, IL, May 4, 2013

25. Atomic Nuclei on the Edge: The Story of 25O
Joseph Bullaro*
Celebration of Learning, Augustana College, Rock Island, IL, May 6, 2015

26. Atomic Nuclei on the Edge: The Story of ^{25}O.
Joseph Bullaro*,
Celebration of Learning, Augustana College, Rock Island, IL, May 6, 2015.

27. Unbound Resonances of ^{26,25}F.
Jacob Herman*, Ali Rabeh*, Matthew Tuttle-Timm*,
Spring 2016 Meeting of the Illinois Section of the AAPT, University of Illinois, Urbana, IL, April 22-23, 2016.

28. Resonances of ^{25,26}F Atomic Nuclei.
Matthew Tuttle-Timm*,
Celebration of Learning, Augustana College, Rock Island, IL, May 3, 2017.

29. Light Output for Unbound Neutron Emission and Simulation Comparison.
Jacob Herman*,
2016 Quadrennial Physics Congress, San Francisco, CA, Nov. 3-5, 2016.

30. Calibration Techniques for Detector Systems in Nuclear Physics.
Charlie Baird,
Indiana University South Bend Undergraduate Research Conference, South Bend, IN, March 31, 2017.

31. Sequential Decay of ^{26}F.
Hayden Karrick*, Nathan Frank, Anthony Kuchera, Caleb Sword, Jaclyn Brett, Paul DeYoung, Michael Thoennessen, MoNA Collaboration,
Celebration of Learning, Augustana College, Rock Island, IL, May 1, 2019.

32. Analysis of Neutron Rich Nuclide.
John McDonaugh, Nathan Frank, Dayah Chrisman, MoNA Collaboration,
Sigma Xi Research Presentations, St. Ambrose University, March 5, 2019.

33. Sequential Decay of ^{26}F.
Hayden Karrick*, Nathan Frank, Anthony Kuchera, Caleb Sword, Jaclyn Brett, Paul DeYoung, Michael Thoennessen, MoNA Collaboration,
Sigma Xi Research Presentations, St. Ambrose University, March 5, 2019.

34. Investigation of a Gas Photo-Multiplier (GPM) Based MoNA-LISA Detector
Malinga Rathnayake, Angel Christopher,, and Paul Gueye
2019 Mid-Michigan Symposium for Undergraduate Research Experiences

35. Multilayered Active target for MoNA Experiments (MAME) - simulation progress report.
Jeffrey Walters,
poster, Southeast/Southwest regional meeting of the National Organization for the Professional Advancement of Black Chemists and Chemical Engineers, Oxford, MS, April (2022).

36. Neutron Unbound Excited States in 27F Produced from 28Ne(-1p).
Kyra Rudolph,
poster, Southeast/Southwest regional meeting of the National Organization for the Professional Advancement of Black Chemists and Chemical Engineers, Oxford, MS, April (2022).

37. Clifton D Kpadehyea, Jaylen I. Rasberry, Thomas Redpath, and the MoNA Collaboration,
DG.00004, DNP2022 Fall meeting of the Division of Nuclear Physics, New Orleans, Oct. 27-30, (2022).

38. Investigation of the reaction mechanism in the spectroscopy of neutron unbound isotopes by the MoNA Collaboration
Jared Bloch, Belen Monteagudo Godoy, Paul Gueye, Thomas Baumann, Thomas Redpath
Michigan State University Undergraduate Research and Arts Forum (2021).

39. Study of a cryogenic cylindrical GEM based target
Rachel Lee (PING2020 student)
Okemos High School Research Symposium (2021).

7.7 MoNA in the Media

1. MoNA: The Modular Neutron Array Video
Bryan Luther
Centennial Scholars Program, Moorhead, MN, February 11, 2003

2. Undergraduates assemble neutron detector
T. Feder
Physics Today, p. 25, March 2005

3. Undergraduates as researchers
MoNA Collaboration
The Chronicle of Higher Education, Letter to the Editor, The Chronicle Review, Vol. 53 ,Issue 33, (April 20, 2007)
`http://chronicle.com/subscribe/login?url=/weekly/v53/i33/33b02102.htm`

4. Raising MoNA
A. Jia
Symmetry Vol. 4 p. 6 Aug. 2007
`http://www.symmetrymagazine.org/cms/?pid=1000511`

5. Giving students a taste of research
M. Thoennessen
Physics World, p. 16, Feb. 2008

6. Going beyond the neutron drip-line with MoNA
J. A. Brown for the MoNA Collaboration
Nuclear Physics News 20, p. 23, 2010

7. Focus: Nuclei emit paired-up neutrons
Michael Schirber
Physics 5, 30 (2012)

8. MoNA makes first confirmed sighting of dineutron decay
CERN COURIER, April 27 (2012)
`cerncourier.com/cws/article/cern/49341`

9. Michigan's MoNA LISA
`http://nscl.msu.edu/general-public/news/2012/michigan039s-mona-lisa`

10. R&D News April 16, 2012
http://goo.gl/EWIxd1

11. Dineutron emission seen for the first time
IOP physicsworld.com, March 14, 2012
http://goo.gl/TD3RAQ

12. Unknown form of nuclear decay
Popular Science, Science and Technology Portal. May 9, 2012
http://popular-science.net/tag/dineutron

13. LIFELONG EXPOSURE TO SCIENCE LEADS TO CAREER IN PHYSICS
Jefferson Laboratory News, February 12, 2020
https://www.jlab.org/news/stories/lifelong-exposure-science-leads-career-physics

14. A college sophomore at age 16, Maya Wallach of Stafford is studying rare isotope beams.
The Freelance-Star, fredericksburg.com
https://fredericksburg.com/news/local/a-college-sophomore-at-age-16-maya-wallach-of-stafford-is-studying-rare-isotope-beams/article_c906c080-e37e-5a53-88ce-43227c6a56e3.html

7.8 MoNA on the Web

1. The MoNA homepage
http://mona.wabash.edu/

2. MoNA Wikipedia article
http://en.wikipedia.org/wiki/Modular_Neutron_Array

3. MoNA YouTube video
http://www.youtube.com/watch?v=qPlsFu5m41s

4. MoNA on Facebook
http://www.facebook.com/pages/Modular-Neutron-Array/143503835659905

5. Research.gov insights into nuclear decay
http://goo.gl/hQw3O8

6. 60 seconds with Maria Massa '18
https://www.youtube.com/watch?v=SLW_Fce2HLA

7. Paul Gueye: The (Hidden) Shades of Physics - Perspectives of being a Black Physicist.
Women and Minorities in Sciences Lecture Series, NSCL/FRIB Summer Virtual Seminar, https://mediaspace.msu.edu/media/Paul+GueyeA+The+%28Hidden%29+Shades+of+Physics+-+Perspectives+of+being+a+Black+Physicist/1_vrojdt99. April 5, 2020

8. MSU video features FRIB'S Paul Guèye (2022)
https://frib.msu.edu/news/2022/msu-video-paul-guÃÍye.html,
January 12, 2022

9. Prof. Paul Gueye receives 2022 Edward A. Bouchet Award from the APS
https://pa.msu.edu/news-events/news/prof-paul-gueye-receives-2022-edward-a-bouchet-award-from-the-a

10. "'You just do it": Paul Guèye earns national distinction
https://msutoday.msu.edu/news/2021/paul-gueye-edward-a-bouchet-award,October15,2021

11. Dr. Paul Gueye wins Bouchet award
https://nsbp.org/news/news.asp?id=58687

12. 2022 Edward A. Bouchet Award Recipient: Paul L. J. Guèye Facility for Rare Isotope Beams, Michigan State University
https://www.aps.org/programs/honors/prizes/prizerecipient.cfm?last_nm=Gueye&first_nm=Paul&year=2022

13. Student View: A chance opportunity that changed my life
`https://msutoday.msu.edu/news/2022/student-view-a-chance-opportunity-that-changed-my-life`,
April 28, 2022

7.9 Publications in Refereed Journals

1. Using passive converters to enhance detection efficiency of 100-MeV neutrons
T. Baumann, H. Ikeda, M. Kurokawa, M. Miura, T. Nakamura, Y. Nishi, S. Nishimura, A. Ozawa, T. Sugimoto, I. Tanihata, and M. Thoennessen
Nucl. Instr. And Meth. A 505, 25 (2003)

2. MONA—The Modular Neutron Array
B. Luther, T. Baumann, M. Thoennessen, J. Brown, P. DeYoung, J. Finck, J. Hinnefeld, R. Howes, K. Kemper, P. Pancella, G. Peaslee, W. Rogers and S. Tabor
Nucl. Instr. And Meth. A 505, 33 (2003)

3. Fabrication of a modular neutron array: A collaborative approach to undergraduate research
R. H. Howes, T. Baumann, M. Thoennessen, J. Brown, P. A. DeYoung, J. Finck, J. Hinnefeld, K. W. Kemper, B. Luther, P. V. Pancella, G. F. Peaslee, W. F. Rogers, and S. Tabor
American Journal of Physics 73, 122 (2005)

4. Construction of a Modular Large-Area Neutron Detector for the NSCL
T. Baumann, J. Boike*, J. Brown, M. Bullinger*, J. P. Bychoswki*, S. Clark*, K. Daum*, P. A. DeYoung, J. V. Evans*, J. Finck, N. Frank, A. Grant*, J. Hinnefeld, G. W. Hitt, R. H. Howes, B. Isselhardt*, K. W. Kemper, J. Longacre*, Y. Lu*, B. Luther, S. T. Marley*, D. McCollum*, E. McDonald*, U. Onwuemene*, P. V. Pancella, G. F. Peaslee, W. A. Peters, M. Rajabali*, J. Robertson*, W. F. Rogers, S. L. Tabor, M. Thoennessen, E. Tryggestad, R. E. Turner*, P. J. VanWylen*, N. Walker*
Nucl. Instr. And Meth. A 543, 517 (2005)

5. Selective population and neutron decay of an excited state of ^{23}O
A. Schiller, N. Frank, T. Baumann, D. Bazin, B. A. Brown, J. Brown, P. A. DeYoung, J. E. Finck, A. Gade, J. Hinnefeld, R. Howes, J.-L. Lecouey, B. Luther, W. A. Peters, H. Scheit, M. Thoennessen, J. A. Tostevin
Phys. Rev. Lett. 99 112501 (2007)

6. Production of nuclei in neutron unbound states via primary fragmentation of ^{48}Ca
G. Christian, W. A. Peters, D. Absalon*, D. Albertson*, T. Baumann, D. Bazin, E. Breitbach*, J. Brown, P. L. Cole*, D. Denby*, P. A. DeYoung, J. E. Finck, N. Frank, A. Fritsch*, C. Hall*, A. M. Hayes*, J. Hinnefeld, C. R. Hoffman, R. Howes, B. Luther, E. Mosby*, S. Mosby*, D. Padilla*, P. V. Pancella, G. Peaslee, W. F. Rogers, A. Schiller, M. J. Strongman, M. Thoennessen, L. O. Wagner*
Nucl. Phys. A801, 101 (2008)

7. Big physics at small places: The Mongol horde model of undergraduate research
P. J. Voss*, J. E. Finck, R. Howes, J. Brown, T. Baumann, A. Schiller, M. Thoennessen, P. A. DeYoung, G. Peaslee, J. Hinnefeld, B. Luther, P. V. Pancella, W. F. Rogers
Journal of College Teaching and Learning 5(2), 37 (2008)

8. Determination of the N = 16 shell closure at the oxygen drip line
C. R. Hoffman, T. Baumann, D. Bazin, J. Brown, G. Christian, P. A. DeYoung, J. E. Finck, N. Frank, J. Hinnefeld, R. Howes, P. Mears*, E. Mosby*, S. Mosby*, J. Reith*, B. Rizzo*, W. F. Rogers, G. Peaslee, W. A. Peters, A. Schiller, M. J. Scott*, S. L. Tabor, M. Thoennessen, P. J. Voss*, and T. Williams* (MoNA Collaboration)
Phys. Rev. Lett. 100, 152502 (2008)

9. Ground state energy and width of ^{7}He from ^{8}Li proton knockout
D. H. Denby*, P. A. DeYoung, T. Baumann, D. Bazin, E. Breitbach*, J. Brown, N. Frank, A. Gade, C. C. Hall*, J. Hinnefeld, C. R. Hoffman, R. Howes, R. A. Jenson*, B. Luther, S. M. Mosby*, C. W. Olson*, W. A. Peters, A. Schiller, A. Spyrou, and M. Thoennessen
Phys. Rev. C 78, 044303 (2008)

10. Neutron decay spectroscopy of neutron-rich oxygen isotopes
N. Frank, T. Baumann, D. Bazin, B. A. Brown, J. Brown, P. A. DeYoung, J. E. Finck, A. Gade, J. Hinnefeld, R. Howes, J.-L. Lecouey, B. Luther, W. A. Peters, H. Scheit, A. Schiller, M. Thoennessen, and J. Tostevin
Nucl. Phys. A 813, 199 (2008)

*undergraduate student

11. Evidence for a doubly magic ^{24}O
C. R. Hoffman, T. Baumann, D. Bazin, J. Brown, G. Christian, D. H. Denby*, P. A. DeYoung, J. E. Finck, N. Frank, J. Hinnefeld, S. Mosby*, W. A. Peters, W. F. Rogers, A. Schiller, M. J. Scott*, A. Spyrou, S. L. Tabor, M. Thoennessen, P. J. Voss*, (MoNA Collaboration)
Phys. Lett. B 672, 17 (2009)

12. Disappearance of the N = 14 shell
M. J. Strongman, A. Spyrou, C. R. Hoffman, T. Baumann, D. Bazin, J. Brown, P. A. DeYoung, J. E. Finck, N. Frank, S. Mosby, W. F. Rogers, G. F. Peaslee, W. A. Peters, A. Schiller, S. L. Tabor, and M. Thoennessen
Phys. Rev. C 80, 021302(R) (2009)

13. First evidence for a virtual ^{18}B ground state
A. Spyrou, T. Baumann, D. Bazin, G. Blanchon, A. Bonaccorso, E. Breitbach*, J. Brown, A. DeLine*, P. A. DeYoung, J. E. Finck, N. Frank, S. Mosby, W. A. Peters, A. Russel*, A. Schiller, M. J. Strongman, and M. Thoennessen
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Z. Kohley, T. Baumann, D. Bazin, G. Christian, P. A. DeYoung, J. E. Finck, R.A. Haring-Kaye, J. Hinnefeld, N. Frank, E. Lunderberg, B. Luther, S. Mosby, W. A. Peters, J. K. Smith, J. Snyder, S.L. Stephenson, M. J. Strongman, A. Spyrou, M. Thoennessen, and A. Volya,
Proceedings of the 3rd International Workshop on State of the Art in Nuclear Cluster Physics (SOTANCP3), Journal of Physics: Conference Series 569, 012033 (2014)

13. Study of Neutron-Unbound States with MoNA
A. N. Kuchera, A. Spyrou, J. K. Smith, T. Baumann, G. Christian, P. A. DeYoung, J. E. Finck, N. Frank, M. D. Jones, Z. Kohley, S. Mosby, W. A. Peters, and M. Thoennessen
Proceedings of the International Symposium on Exotic Nuclei, EXON 2014, edited by Yu. E. Penionzhkevich and Yu. G. Sobolev, p. 625, World Scientific (2015)

14. Search for 4n contributions in the reaction ^{14}Be(CH$_2$,X)^{10}He.
M. D. Jones, Z. Kohley, T. Baumann, G. Christian, P. A. DeYoung, J. E. Finck, N. Frank, R. A. Haring-Kaye, A. N. Kuchera, B. Luther, S. Mosby, J. K Smith, J. Snyder, A. Spyrou, S. L. Stephenson, M. Thoennessen,
Proceedings of the 21st International Conference on Few-Body Problems in Physics, EPJ Web of Conferences 113, 06006 (2016).

7.11 Articles, Presentations, and Publicity Related to Broader Impact

7.12 MoNA Experiments at the NSCL

Experiment	Year	Spokesperson	Title	Status
discretionary	2002		micro MoNA	
03502	2003	W. A. Peters	MoNA test run	[12]
04503	2004	N. Frank	Sweeper magnet test	[18]
03048	2004	J. Finck	Ground state wave function of ^{12}Be	[62–65]
03033	2004	J.-L. Lecouey	Is ^{24}O a doubly magic nucleus?	[18, 66–72]
03038	2005	A. Kiss	Coulomb-breakup of neutron-rich nuclei	[73, 74]
05502	2005	P. DeYoung	^{7}He breakup	[75]
05039	2005	P. DeYoung	Going beyond the $N = 16$ shell in oxygen	[76–81]
05033	2005	P. DeYoung	Population of neutron-unbound states from direct fragmentation, test	completed (see 05124)
05034	2006	A. Schiller	Two-neutron decay of ^{13}Li	[82, 36, 83]
06504	2006	M. Thoennessen	Sweeper magnet beam blocker test	completed
05124	2006	W. A. Peters	Neutron-dripline studies with direct fragmentation	[84, 85]
07503	2007	W. A. Peters	Measurement of MoNA's Efficiency	[63]
06025	2008	T. Baumann	Di-neutron decay of ^{16}Be	[86, 87, 38, 88–90, 83, 91, 92]
08016	2008	A. Spyrou	Ground State of Neutron-Unbound ^{24}N	insufficient statistics, [93]
08026	2008	A. Schiller	Two-Neutron Decay from the ground state of ^{26}O	[39, 94, 95, 90, 89, 83, 46]
07039	2009	P. DeYoung	Ground-State Neutron Decay of ^{21}C	[96–98]

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Experiment	Year	Spokesperson	Title	Status
09040	2010	N. Frank	Study of Neutron Unbound States in ^{28}F	[99, 50, 100, 101]
09069	2010	M. Mosby	Excitation Energy of Neon Prefragments	[102, 103]
09067	2010	P. DeYoung	^{15}Be Ground State Formed via a (d,p) Reaction	[104–106, 83, 107, 108]
09028	2010	A. Schiller	^{24}O Neutron Knockout to ^{23}O Excited States	Ohio University, yielded no results
10023	2011	W. Rogers	Unbound States in Neutron-Rich Oxygen Isotopes	[109]
11506	2012	J. K. Smith	Sweeper Hodoscope Commissioning	
10007	2012	J. K. Smith	Two-neutron decay of ^{11}Li	[110–113, 45]
11027	2013	W. A. Peters	(d,n) studies using MoNA-LISA and VANDLE	Oak Ridge, yielded no results
11028	2014	D. Bazin	Knockout reactions on *p*-shell nuclei	manuscript under review
12004	2014	N. Frank	Determination of the energy gap between the $sd-pf$ neutron shells in ^{25}O	[114, 107, 115, 116, 53]
12011	2014	Z. Kohley	Exploring the Equation of State with RIBs	[117]
14014	2015	A. Kuchera	Understanding two-nucleon unbound systems	[9]
15091	2017	P. DeYoung	Measurement of ^{9}He ground and excited states	[118, 119]
15118	2016	N. Frank	Lifetime measurements with the decay-in-target method	[55, 42]
16027	2017	A. Kuchera	Neutron unbound states in the island of inversion	[120, 121]
19504	2020	N. Frank	Charged particle detector telescope test	
18025	–	C. Hoffman	First Empirical Limits on the One-Neutron Separation Energy in ^{28}O	canceled due to end of CCF operations
19013	2020	P. DeYoung	Are there unexpected structural changes in ^{13}Be?	analysis in progress

7.13 MoNA Experiments at LANSCE

Experiment	Year	Spokesperson	Title	Status
NS-2015-6975-A	2016	W. F. Rogers	Direct Observation of Neutron Scattering in MoNA-LISA Scintillator Detectors	[122]
NS-2019-8230	2019	A. N. Kuchera	Neutron Scattering Angluar Distributions in Plastic Scintillators	analysis in progress
NS-2022-9156	2022-23	A.N. Kuchera	Measurements of Neutron Scattering from Carbon Using a Diamond Detector	planning stage

8 People

8.1 MoNA Undergraduate Students

Name	Institution	Year	Degree	Employment
Melanie Evanger	Concordia	2001–2002	MSE	Sr Principal Engineer
Maria-Teresa Herd	Bryn Mawr	2001–2002	PhD	Assistant Professor
Mustafa Rajabali	Concordia	2001–2002	PhD	Associate Professor
Ramsey Turner	Concordia	2001–2002	BS	Solutions Architect
Anna Volftsun	Bergen Ct. HS	2001–2002	MA	General Counsel
Paul Yeager	Michigan State	2001–2002	BS	Business Analyst
Joseph Bychowski	Hope	2002–2003	MS	Sales Engineer
Jim Evans	IUSB	2002–2003	MS	Consultant
Tony Grant	Millikin	2002–2003	MS	Software Test Analyst
Brett Isselhardt	Westmont	2002–2003	PhD	Staff Scientist, LLNL
Walter Kiefer	Western Michigan	2002–2003		
Adam Lincoln	Western Michigan	2002–2003	PhD	Data Scientist
James Longacre	Ball State	2002–2003		Rad. Safety Officer
Yao Lu	Okemos HS	2002–2003		
Scott Marley	IUSB	2002–2003	PhD	Assistant Professor
David McCollum	Ball State	2002–2003		
Eric McDonald	Central Michigan	2002–2003	BS	Principal Engineer
Uchenna Onwuemene	Millikin	2002–2003	MS	Structural Engineer
Jennifer Robertson	Ball State	2002–2003	PhD	Editor
Erik Strahler	Michigan State	2002–2003	PhD	Software Developer
Peter VanWylen	Hope	2002–2003		
Jennifer Boike	Central Michigan	2003–2004		
Sarah Clark	Westmont	2003–2004		
Kevin Daum	Central Michigan	2003–2004	MA	Clinical Therapist
Eric Johnson	Nebraska Wesleyan	2003–2004	PhD	Chief Actuary Officer
Jon Lowry	Concordia	2003–2004	BSE	Owner/ Civil Engineer
Nathan Walker	Westmont	2003–2004		
Lance Elliot	Westmont	2004–2005	BS	Chem. Hygiene Officer
Draik Hecksel	Wabash	2004–2005	PhD	Medical Physicst
Utsab Khadka	Hope	2004–2006	PhD/MBA	MBA Manager
Matt Kleber	Concordia	2004–2005	BA	Technical Engineer
Patrick Mears	Hope	2004–2005	PhD	Sr Syst. Integration Specialist
Jason Miller	Concordia	2004–2005	MS	
Abe Pena	Texas	2004–2005	PhD	Sr Software Engineer
Robert Pepin	Gonzaga	2004–2005	PhD	Director
Tina Pike	Hope	2004–2005	PhD	Lead Medical Physicist
Justin Reith	Hope	2004–2006	MD	Hospitalist
Benjamin Rizzo	Marquette	2004–2006	PhD	Postdoc
Michael Strongman	Westmont	2004–2005	MS	Physical Scientist
Andrew Stump	Michigan State	2004–2005	MA	Development Director
Phil Voss	Central Michigan	2004–2006	PhD	Appl. Metrology Engineer
Kyle Watters	Westmont	2004–2005	PhD	Professor of Physics
Ziqi Dai	Marquette	2005–2006	PhD	Software Engineer
Evan Mosby	Westmont	2005–2007	MBA/MS	Sr. Software Dev. Engineer
Shea Mosby	Westmont	2005–2007	PhD	Staff Scientist
Andrew Ratkiewicz	IUSB	2005–2006	PhD	Staff Scientist
Mike Scott	Central Michigan	2005–2006	PhD	Associate Director of Supply Chain
Ted Williams	Wabash	2005–2006	PhD	Principal Engineer
Daniel Absalon	Marquette	2006–2007	MS	Escalation Engineer
Daniel Albertson	Concordia	2006–2007	MA	Director of Global Learning
Eric Breitbach	Marquette	2006–2007	MS	R&D Physicist

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Name	Institution	Year	Degree	Employment
Perrie Cronin-Cole	Concordia	2006–2007	MSE	Design Engineer
Amy DeLine	Central Michigan	2006–2007	BS	Mortgage Coordinator
Deb Denby	Hope	2006–2008		
Adam Fritsch	Wabash	2006–2008	PhD	Assoc. Professor
Jamie Gillette	Westmont	2006–2007		
Chris Hall	Hope	2006–2008	PhD	Research Scientist
Anne Hayes	Minnesota Morris	2006–2007		
Katherine McAlpine	Michigan State	2006–2007	BA	Sr. Writer & Asst. News Editor
Malinda Reese	Westmont	2006–2007	BA	Transportation Engineer
Patrick O'Rourke	Wabash	2006–2007		
Derek Padilla	UC San Diego	2006–2007	PhD	Company Co-founder
Lucas Wagner	Concordia	2006–2007	PhD	Software Engineer
Edward White	Notre Dame	2006–2007	PhD	Research Consultant
Meghan Winer	Hope	2006–2007		
Tova Yoast-Hull	Kenyon	2006–2007	PhD	Teacher
Mike Heim	Marquette	2007–2008	MS	Industrial CT Scanning
Robert Jensen	Concordia	2007–2008	MS	R&D Design Engineer
Chris Olsen	Concordia	2007–2008	MSc	Assoc. Principal Biostatistician
Michael Gardner	Westmont	2007–2008	PhD	Data Scientist
Janelle Bailey	Illinois Wesleyan	2007–2008		attorney
Michael Bennett	Westmont	2007–2009	PhD	Director of Education
John Novak	Western Michigan	2008–2009	PhD	Director of Computer Vision
Stephen Quinn	Notre Dame	2008–2009		
Alison Smith	Illinois Wesleyan	2008–2009		Designer
Mark Kasperczyk	Illinois Wesleyan	2008–2009	PhD	Application Scientist
Elizabeth Hook	Rhodes	2008–2009	BS	Senior Consultant
Rob Anthony	Ohio Wesleyan	2009–2010		
Steven Ash	Augustana	2009–2011	BA	Principal Software Engineer
Alegra Aulie	Westmont	2009–2010	BSc	Senior Test Engineer
Nicholas Badger	Rhodes	2009–2010	PhD	Reliability Program Manager
Hengzhi Chen	Ohio Wesleyan	2009–2010	MS	Software Engineer
Casey DeRoo	Concordia	2009–2010	PhD	Assistant Professor
Lewis Elliot	Westmont	2009–2010	MS	Engineering Manager
Ben Foster	Wabash	2009–2010	MS	Senior Engineer
Amanda Grovom	Westmont	2009–2011		
Autumn Haagsma	Central Michigan	2009–2011	MS	Research Geochemist
Alex Howe	Ohio Wesleyan	2009–2010	PhD	Postdoc
Megan Jacobsen	Concordia	2009–2010	PhD	Chief Med. Physics Fellow
Philip Kasavan	Westmont	2009–2010	MS	Electrcial Engineer
Steve Kuhn	Earlham	2009–2010	PhD	PostDoc
Matthew Miller	Rhodes	2009–2010	BS	Software Developer
Tim Nagi	Hope	2009–2010	BS	Production Process Engineer
Sam Novario	Notre Dame	2009–2010	PhD	Research Scientist
Mathieu Ndong	IUSB	2009–2010		
Alexander Peters	Gettysburg	2009–2011	BS	Software Engineer
Kimberly Purtell	Central Michigan	2009–2010		
Kaitlynne Rethman	Central Michigan	2009–2011		Peace Corp
Logan Rice	Wabash	2009–2010	MS	PhD Candidate
Sam Stewart	IUSB	2009–2010		
Zach Torstrick	IUSB	2009–2010		
Brad Vest	Wabash	2009–2010	BA	Technical Operations Director
Mark Warren	Augustana	2009–2011	PhD	Research Associate
Alissa Wersal	Montana	2009–2010	BS	Cust. Experience Director
Dan Barofsky	Central Michigan	2010–2011		

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Name	Institution	Year	Degree	Employment
Stuart Casarotto	Augustana	2010–2012	BA	Senior Software Engineer
Kendra Elliston	Gettysburg	2010–2011	MS	Chief Commercial Officer
Taimur Islam	Ohio Wesleyan	2010–2013	PhD	Engineer
Eric Lunderberg	Hope	2008–2011	PhD	
James McGugan	Colorado College	2010–2011	BA/BS	Design Engineer
Katelyn Montgomery	Central Michigan	2010–2011		
Meredith Sargent	Idaho	2010–2011	PhD	Postdoc
Chris Simmons	IUSB	2010–2011	Mdivd	
Kristen Stryker	Gettysburg	2010–2011	MS	Medical Physicist
Rachael Tomasino	Central Michigan	2010–2011		Graduate Student
Caitlin Taylor	Hope	2010–2011	PhD	Scientist
Eric Traynor	Hope	2010–2013	BA	Solutions Architect
Natalie Viscariello	Augustana	2010–2012	PhD	
Jonathan Wong	Wabash	2010–2012	BA/BS	Technologies
Peter Draznik	Augustana	2011–2012	MS	Data Scientist
Mark Hoffman	Augustana	2011–2012	MS	Software Engineer
Ben Pigg	Ohio Wesleyan	2011–2012	BA/BE	Princial Mech. Engineer
April Ploeger	Pennsylvania	2011–2012		
Richard Scotten	Fullerton College/OWU	2011–2012	BA	Company Founder
Nathan Smith	Augustana	2011–2012	MS	Research Specialist
Kyle Williams	Augustana	2011–2012	BA	Product Support Agent
Alicia Palmisano	Gettysburg	2011–2014	PhD	Postdoc
Magdalene McArthur	Howard	2011–2012	BS	Information Techn. Analyst
David Thompson	Gettysburg	2012–2014	MS	Software Engineer
Kevin Krautbauer	Concordia	2011–2012	MSE	Mechanical Engineer
Sierra Garrett	Westmont	2012–2013	BS	Ops. Accelerator Engineer
Alyson Barker	Westmont	2012–2013	BS	PhD Student
Nathaniel Taylor	Westmont	2012–2013	BS	Software Engineer
Bethany Sutherland	Westmont	2011–2012	BS	Interim Executive Director
Jackson Kwiatkowski	Westmont	2011–2012	BS	Company Founder
Abdul Merhi	Augustana	2012–2013	MSE	
Franz Utermohlen	Gettysburg	2013–2014	PhD	Technical Staff
Andrew Lulis	Augustana	2012–2013	BS	Customer Service Rep.
Zach Ingbretson	Concordia	2012–2013	MSE	Design Engineer
Glenn Patterson	Wabash	2012–2013		
Jaclyn Brett	Hope	2012–2013	BS	Interim Kids Program CoDirector
Braden Marks	Hope	2012–2013	BS	Testing Technician
Mark Klehfoth	IUSB	2010–2011	MS	PhD student
Caleb Bancroft	Central Michigan	2013–	BS	Winemaker
Richard Adam Bryce	Central Michigan	2014–	PhD	
Joseph Bullaro	Augustana	2014–2016	BA	Economic Consultant
Heather Garland	Gettysburg	2014–	BA	Grad Student
Elizabeth Havens	Central Michigan	2014–	BS	Graduate Student
Rachel Parkhurst	Westmont	2014–	BA	STEM Specialist
David Hicks	Central Michigan	2013–2014	PhD	Principal Engineer
Eli McDonald	Augustana	2014	BE	Graduate Student
Andy Dong	Wabash	2014–2015	BA/BSE	Electrical Engineer
Inbum Lee	Wabash	2014–	BA	PhD Candiate
Sam Wilensky	Gettysburg	2015–	BS	Admissions Counselor
Maria Mazza	Gettysburg	2015–2018	MS	PhD student
Tim Seagren	Westmont	2015–2016	BS	Senior Engineer
Aria Hamann	Westmont	2015–2016	BS	Graduate Student
Ali Rabeh	Augustana	2015–2017	MSE	Grad. Res. Assistant
Lauren Quednau	Augustana	2015	BA	PhD student
Matthew Tuttle-Timm	Augustana	2015–2017	BA	

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Name	Institution	Year	Degree	Employment
Savannah Gowen	Mt. Holyoke/OW REU	2015–2016	BS	Graduate Student
Chin Lung Tan	Ohio Wesleyan	2015–2016	MA	Graduate Student
Jon Daron	Wabash	2015–2016	BA	Process Engineer
Tim Riley	Wabash	2015–2018	MEd	Physics Teacher
Cole Persch	Hope	2016–2018	BA	Grad. Res. Assistant
Caleb Sword	Hope	2016–2018	MS	Software Engineer
Peter Christ	Gettysburg	2016–2017	ME	Structural Engineer
Nathaniel Lashley	Howard Univ./MSU SROP	2016	BS	Graduate Student
Jacob Herman	Augustana	2016–2017	BA	Laboratory Analyst
Hayden Karrick	Augustana	2017–2019	BA	Graduate Student
Charlie Baird	IUSB	2016–2017	MS	Software Engineer
Tyler Mix	Wabash	2017–2018	MS	
Cody Cochran	Wabash	2017–2018	BA	PhD Candidate
Jonathan Hu	Gettysburg	2017–2018	BS	Jr. Engineer
Edith Tea	Gettysburg	2017–2019	MS	Business Developer
Jordan Owens	Rensselaer/Hampton	2017–		
Makiyah Neal	VA Union/Hampton REU	2017		
Matthew Jamari O'Neal	Hampton	2017	BS	
Angel Christopher	Hampton	2017–2019	BS	
James Boone	Indiana Wesleyan	2017	BS	Analytical Technician
Andrew Wantz	Indiana Wesleyan	2017–2019	BS	Grad Student
William vonSeeger	Hope	2018	BS	Grad Student
Spencer Shank	Wabash	2018	BA	Software Engineer
Koty Hall	Wabash	2018	BA	Interchange Analyst
Tan Phan	Davidson College	2017–2018	PhD	Medical Physicist
Robbie Seaton-Todd	Davidson College	2017–		Project Lead
John McDonaugh	Augustana	2018–2020	BA	Grad Student
Georgia Votta	Augustana	2019–2021	BA	Grad Student
Rida Shahid	Davidson College	2019	BS	Software Engineer
Maya Watts	MSU	2019–2020	BS	Grad Student
Alder Fulton	MSU	2019–		
Jeremy Hallett	Indiana Wesleyan	2019–2021		
William Lillis	Wabash	2019–2020		Grad Student CS/Umass
Pham Phuonganh	MSU	2020–		
Paige Lyons	MSU	2020–		
Anita Agasaveeran	MSU	2020–		
Grant Bock	Morgan State	2020–2021		
Yannick Guèye	MSU	2020–		
Jared Bloch	MSU	2020–		
Alaura Cunningham	Virginia State	2020–2021	BS	Grad Student
Dexter Smith	Central Florida/MSU SROP	2020		
Maya Wallach	Stratford HS/MSU	2020–		
Andrea Robinson	Davidson College	2020	BS	Grad Student
Caroline Capuano	Davidson College	2020	BS	
Ralph Peterson-Veatch	Augustana	2020-2022	BA	
Andrew Rippy	Wabash	2020	BA	Grad Student
Andrea Munroe	Indiana Wesleyan	2020–2021		
Jason Reinoehl	IUSB	2020–		
Hannah Erington	Univ. of Texas/MSU REU	2021		Grad Student
Forest Rulison	Hope	2021	BS	Grad Student
Olivia Guarinello	Davidson College	2021		Student
Ari Maki	Davidson College	2021–2023	BS	Scientist
Anas Akkar	Augustana	2021–2022	BA	
Furman Doty II	Augustana	2021–2022	BA	Online Physics Tutor and Grader

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Name	Institution	Year	Degree	Employment
Henry Webb	Augustana	2021–2023	BA	Grad Student
Molly Garrison	Augustana	2022–		
Colin Hogan	Augustana	2022–		
Tahmid Awal	Davidson College	2022		Student
Kenneth Wang	Davidson College	2022		Student
Derick Flores Madrid	Indiana Wesleyan U	2022		Student
Jenna Smith	Taylor University	2022		Student
Miguel Castelan	Hope College	2022–2023		
Clifton Kpadehyea	Virginia State	2021–2023	BS	
Kyra Rudolph	Virginia State	2021–2022	BS	
Jeffrey Walters	Virginia State	2021–2023	BS	
Kayla Mills	Virginia State	2022	BS	
Jaylen Rasberry	Virginia State	2022–		
Megan Brayton	Virginia State	2021	BS	
Darrius Sykes	Virginia State	2021	MS	
Anna Brandl	MSU	2022–		Student
Justin Schmitz	MSU	2022–		Student
Emily Holman	MSU	2022–		Student
Sara Tatreau	MSU	2022		Student
Thomas Webb	MSU	2022	BS	BS-MSU engineering
Turuu Ariunbold	MSU	2022–		Student
Miles Klapthor	MSU	2022–		Student
Jeremy Rebenstock	MSU	2022–		Student
Faith Cherop	MSU	2022–		Student
Ebony Cakzander	MSU	2022–		Student
Joshua Marshall	Morgan State University	2022		Student
Donovan Flagg	University of Missouri	2022		Student
Jayla Edwards	MSU	2022		Student
Dominic Davis	Morgan State University	2022		Student
Eric Pierce	Virginia Union University	2022		Student
Shane Winner	Davidson College	2023		Student
Bianca Hassan	Davidson College	2023		Student
Isiah Leonard	Virginia State University	2023 –		
Bishop Carl	Hope College	2022–		student
Wesley Sussenbach	Indiana Wesleyan University	2023		Student
Olivia Lucas	Indiana Wesleyan University	2023		Student
Rodrigo Garcia	North Eastern Illinois University/MSU SROP	2023		
Kevin Eisenberg	MSU	2023-		Student
Alejandro Florez	University of Houston	2023-		
Jeseleth Benavides	University of Houston	2023-		
Hidalgo Mudonhi	Alabama Agricultural and Mechanical University	2023-		
Dai'Zeiona Finley	Jackson State University	2023-		
Isaac Anokye	Alabama Agricultural and Mechanical University	2023-		
Kyle Zahney	Navajo Technical University	2023-		
Prithak Shrestha	Alabama Agricultural and Mechanical University	2023-		
Tiya Patel	MSU	2023-		

8.2 MoNA Graduate Students

Name	**Affiliation**	**Graduated**	**Experiment**	**Project/Title of Thesis**
Nathan Frank	MSU	2006	03033	Spectroscopy of neutron unbound states in neutron rich oxygen isotopes
	Associate Professor, Augustana College, Rock Island, IL			
William Peters	MSU	2007	03048	Commissioning and first results from MoNA
	Radiation Safety Officer, Niowave Inc., Lansing MI			
Calem Hoffman	FSU	2009	05039	Investigation of the neutron-rich oxygen isotopes at the dripline
	Physicist, Argonne National Laboratory, Lamont IL			
Greg Christian	MSU	2008	05124	Production of unbound nuclei via fragmentation; *MS thesis*
	Assistant Professor, Saint Mary's University, Nova Scotia Canada			
		2011	09040	Spectroscopy of neutron unbound fluorine
	Assistant Professor, Texas A&M, College Station, TX			
Michael Strongman	MSU	2011	08016	Neutron spectroscopy of ^{22}N and the disappearance of the N = 14 shell; *MS thesis*
	Patrick Air Force Base, FL			
Shea Mosby	MSU	2011	07039	Spectroscopy of neutron unbound states in neutron rich carbon
	Staff Scientist, LANL, NM			
Jesse Snyder	MSU	2013	09067	^{15}Be via (d,p)
	Postdoc in Medical Physics, University of Iowa			
Jenna Smith	MSU	2014	10007	Two-neutron decay of ^{11}Li
	Assistant Professor, Pierce College, Seattle WA			
Michael Jones	MSU	2016	12004	^{24}O (d,p)
	Postdoctoral Research Associate, University of North Carolina, Chapel Hill NC			
Jessica Freeman	Hampton		15118	Calibration of the Si-Be segmented target for ^{26}O life-time experiment; *left 2016*
Krystin Stiefel	MSU	2018	12011	Measument and Modeling of Fragments and Neutrons Produced from Projectile Fragmentation Reactions
	Experiment Safety Engineer, Oak Ridge National Laboratory, Knoxville TN			
Thomas Redpath	MSU*	2019	15118	Lifetime measurements with decay-in-target method
	Visiting Assistant Professor, Virginia State University			
Han Liu	MSU	2019	14014	Understanding two-neutron unbound systems
Daniel Votaw	MSU*	2019	15091	Measurement of ^{9}He ground and excited state
Dayah Chrisman	MSU*	2022	16027	Neutron unbound states in the island of inversion
Ameer Blake	Hampton	2020		Development of a GEM based segmented target for the study of unbound nuclei; *MS thesis*

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Name	Affiliation	Graduated	Experiment	Project/Title of Thesis
Malinga Nathrayake	Hampton	2019		CAD drawing using OnShape and GEANT4 simulation for GEM based neutron detector; *MS thesis*
Xinyi Wang	MSU		19013	Are there unexpected structural changes in ^{13}Be?
Henry Thurston	MSU			*left 2020*
Andrew Wantz	MSU		21066	First Neutron scattering on carbon using a diamond target
Nicholas Mendez	MSU		21016	Neutron unbound excited states in ^{53}Ca
Georgia Votta	MSU			Search for ^{23}C
Letrell Harris	MSU			*left 2022*
Hannah Erington	MSU			
Ambar Rodriguez	MSU			
Thomas Webb	MSU			*left 2022*
Yamina Bennour	University of Orléans, France			Development of a Cherenkov detector for MoNA experiment
David Lempke	MSU			Coulomb breakup of 37Mg

8.3 Other Graduate Students

These students were mentored by researchers outside the MoNA Collaboration.

Name	Affiliation	Start	Graduated	Experiment	Project/Title of Thesis	Current Position
Rudolf Izsak	Budapest	2005	2013	03038	Coulomb-breakup of neutron-rich nuclei	Electronic and Computer Engineering, Brunel University, London
Michelle Mosby	MSU	2007	2014	09069	Excitation energy of neon prefragments	Scientist, LANL, NM
Dilupama Divaratne	Ohio U	2008	2013	09028	^{24}O neutron knockout to ^{23}O excited states	Director of SCIDOME, Lecturer in Physics, OSU

Other graduate students that worked on MoNA projects

Name	Affiliation	Year	Current Position
Harsha Attanayake	OU	2008	Engineering company in Columbus, OH
Adeleke Adeyemi	Hampton	2014	International Monetary Fund
Nathaniel Lashley	Hampton	2016	graduate student
Felix Ndayisabye	MSU	2017	graduate student
Henry Thurston	MSU	2023	unknown

*supported by NNSC

8.4 MoNA Post-Doctoral Researchers

Name	Dates	Current Position
Jean-Luc Lecouey	2003–2005	Staff Physicist, LPC Caen, France
Ken Yoneda	2003–2005	Laboratory Head, RIKEN, Japan
Andreas Schiller	2003–2007	Research Scientist, Norwegian Defence Research Establishment, Oslo, Norway
Heiko Scheit	2006	Research Scientist, GSI, Germany
Artemis Spyrou	2007–2009	Professor, Michigan State University, East Lansing, MI
Zachary Kohley	2011–2012‡	Kohley's Superior Water & Propane, Muskegon, MI
Anthony Kuchera	2014–2017‡	Associate Professor, Davidson College, Davidson, NC
Belén Monteagudo Godoy	2020–2021‡	Associate Professor, Hope College, Holland, MI
Thomas Redpath	2020–2021	Virginia State University
Bineta Lo Amar	2021–	Assistant Professor at UCAD/IMEM, Dakar, Senegal
Ryan Williams	2022–	Assistant Professor at UCAD/IMEM, Dakar, Senegal
Gabriella Mankovskii	2023–	Postdoctoral Fellow

8.5 MoNA Institutions Through the Years

Argonne National Laboratory
Augustana College
Ball State University
Central Michigan University
Concordia University
Davidson College
Florida State University
Gettysburg College
Hampton University
Hope College
Indiana University South Bend
Indiana Wesleyan University
James Madison University
Michigan State University
Milikin Universiy
Ohio Wesleyan University
Rhodes College
St. Johns College
Wabash College
Western Michigan University
Westmont College
Virginia State University

‡supported by NNSC

8.6 MoNA Collaboration Directors

Year	Name	Institution
2001–2002	Bryan A. Luther	Concordia College
2002–2003	Thomas Baumann	Michigan State University
2003–2004	Joseph E. Finck	Central Michigan University
2004–2005	Paul A. DeYoung	Hope College
2005–2006	James A. Brown	Wabash College
2006–2007	Jerry D. Hinnefeld	Indiana University at South Bend
2007–2008	Warren F. Rogers	Westmont College
2008–2009	Paul A. DeYoung	Hope College
2009–2010	Bryan A. Luther	Concordia College
2010–2011	Deseree Meyer	Rhodes College
2011–2012	Nathan Frank	Augustana College
2012–2013	Robert Haring-Kaye	Ohio Wesleyan University
2013–2014	Sharon Stephenson	Gettysburg College
2014–2015	Warren Rogers	Westmont College
2015–2016	James A. Brown	Wabash College
2016–2017	Joe Finck	Central Michigan University
2017–2018	Paul Gueye	Hampton University
2018–2019	Sharon Stephenson	Gettysburg College
2019–2020	Anthony Kuchera	Davidson College
2020–2021	Warren Rogers	Indiana Wesleyan University
2021–2022	Nathan Frank	Augustana College
2022–2023	Thomas Redpath	Virginia State University
2023–	James A. Brown	Wabash College

8.7 Awards

1. Paul DeYoung: 2001 Prize for a Faculty Member for Research in an Undergraduate Institution.
2. Michael Thoennessen: 2005 APS Division of Nuclear Physics Fellow.
3. Calem Hoffman: 2010 APS Dissertation Award in Nuclear Physics.
4. Paul DeYoung: 2012 APS Forum on Education Fellow.
5. Michael Thoennessen: 2012 DNP Mentoring Award.
6. Kaitlynne Rethman: one of the inaugural "10 under 10" awards from CMU. www.e-digitaleditions.com/i/320292, 2014.
7. Sharon Stephenson: Johnson Center for Creative Teaching and Learning Excellence In Teaching Award, 2015.
8. Warren Rogers: 2018 Prize for a Faculty Member for Research in an Undergraduate Institution.
9. Nathan Frank: 2019 Quad Cities Engineering and Science Council (QCESC) Senior Scientist of the Year.
10. Paul L. J. Guèye: 2022 Edward A. Bouchet Award.

8.8 Undergraduate Faculty Grants

1. RUI: Radioactive nuclear beam physics with undergraduates at Hope College
   Paul A. DeYoung and Graham F. Peaslee
   NSF 0098061, 06/01/2001–05/31/2005
2. MRI: Construction of one layer of a highly efficient neutron detector to study neutron-rich rare isotopes at the NSCL (Hope College)
   Paul A. DeYoung and Graham F. Peaslee
   NSF 0132405, 09/01/2001–12/31/2004
3. MRI: Construction of one layer of a highly efficient neutron detector to study neutron-rich rare isotopes at the NSCL
   Joseph Finck
   NSF 0132532, 09/01/2001–08/31/2004

4. MRI: High efficency neutron detector layer
   James Brown
   NSF 0132507, 0432042, 09/01/2001–08/31/2004

5. MRI: Construction of a Layer of a Highly Efficient Neutron Detection Wall for NSCL (IUSB)
   Jerry Hinnefeld
   NSF 0132567, 09/01/2001–08/31/2004

6. MRI: Fabrication of One Layer of a High-Efficiency Neutron Detector
   Ruth Howes
   NSF 0132367, 09/01/2001–08/31/2004

7. MRI: Constructing a Layer for the Large Neutron Detector at NSCL
   Paul Pancella
   NSF 0132438, 09/01/2001–08/31/2004

8. MRI: A Highly Efficient Neutron Detector Array to Study Neutron-Rich Rare Isotopes at the NSCL
   Bryan Luther
   NSF 0132725, 09/01/2001–08/31/2004

9. MRI: Large high-efficiency neutron array detector at MSU
   Warren Rogers
   NSF 0132641, 09/01/2001–08/31/2003

10. RUI: Multifaceted opportunities in nuclear physics for undergraduates at Hope College
    Paul A. DeYoung and Graham F. Peaslee
    NSF 0354920, 05/15/2004–04/30/2008

11. Nuclear physics research at Westmont College
    Warren Rogers
    NSF 0502010, 06/01/2005–05/31/2010

12. An RUI proposal to investigate the neutron drip line using the Modular Neutron Array
    Joseph Finck
    NSF 0555439, 07/15/2006–06/30/2009

13. RUI: Using MoNA, exploring neutron unbound states in nuclei near and beyond the neutron dripline
    James Brown
    NSF 0555488, 07/01/2006–06/30/2010

14. RUI: Fundamental and applied nuclear physics with undergraduates
    Paul A. DeYoung and Graham F. Peaslee
    NSF 0651627, 05/15/2007–04/30/2011

15. RUI: Studying exotic nuclei with the Modular Neutron Array (MoNA)
    Joseph Finck
    NSF 0855456, 9/01/2009–08/31/2012

16. MRI-Consortium: Development of a neutron detector array by undergraduate research students for studies of exotic nuclei
    Bryan Luther NSF 0922559, 10/01/2009–09/30/2012

17. MRI-Consortium: Development of a neutron detector array by undergraduate research students for studies of exotic nuclei
    Robert Kaye
    NSF 0922409, 10/01/2009–09/30/2012

18. MRI-Consortium: Development of a neutron detector array by undergraduate research students for studies of exotic nuclei
    Deseree Meyer
    NSF 0922473, 10/01/2009–09/30/2012

19. MRI-Consortium: Development of a neutron detector array by undergraduate research students for studies of exotic nuclei
Sharon Stephenson
NSF 0922335, 10/01/2009–09/30/2012

20. MRI-Consortium: Development of a neutron detector array by undergraduate research students for studies of exotic nuclei
James Brown
NSF 0922446, 10/01/2009–09/30/2012

21. MRI-Consortium: Development of a neutron detector array by undergraduate research students for studies of exotic nuclei
Jerry Hinnefeld
NSF 0922537, 10/01/2009–09/30/2012

22. MRI-Consortium: Development of a neutron detector array by undergraduate research students for studies of exotic nuclei
Joseph Finck
NSF 0922462, 10/01/2009–09/30/2012

23. MRI-Consortium: Development of a neutron detector array by undergraduate research students for studies of exotic nuclei
Warren Rogers
NSF 0922622, 10/01/2009–09/30/2012

24. MRI-Consortium: Development of a neutron detector array by undergraduate research students for studies of exotic nuclei
Paul A. DeYoung and Graham F. Peaslee
NSF 0922794, 10/01/2009–09/30/2012

25. RUI: Studies of unstable neutron-rich nuclei and interdisciplinary applications of nuclear physics with undergraduates
Paul A. DeYoung
NSF 0969058, 05/15/2010–04/30/2013

26. RUI: Establishing an Undergraduate Research Group in Nuclear Physics
Nathan Frank
NSF 0969173, 09/15/2010–08/31/2014

27. RUI: Study of light exotic nuclei near the neutron dripline
Warren Rogers
NSF 1101745, 05/15/2011–05/14/2014

28. RUI: Studies of exotic nuclei with the MoNA LISA neutron detectors
Joseph Finck
NSF 1205357, 06/01/2012–05/31/2016

29. RUI: Neutron physics from ^{4}He to the edge of the dripline
Sharon Stephenson
NSF 1205537, 10/1/2012–09/30/2015

30. RUI: Cutting-Edge Nuclear Physics Research (Collaborative and Interdisciplinary) at Hope College
Paul A. DeYoung
NSF 1306074, 06/15/2013–05/31/2016

31. Active target development for the study of neutron-unbound nuclei
P. Gueye, M. Thoennessen, and N. Frank
NSSC-MSI Research Grant Award, NNSA, 1/1/2013- 12/31/2015

32. RUI: Undergraduate Research on Neutron-Rich Nuclei
Nathan Frank
NSF 1404236, 08/1/2014–07/31/2017

33. RUI: Study of Exotic Neutron-Rich Nuclei at Westmont College and NSCL,MSU
Warren Rogers
NSF 1506402, 07/15/2015–07/14/2018

34. RUI: High Impact Nuclear Physics Research with Undergraduates
Paul DeYoung and Graham Peaslee
NSF 1613188, 06/1/2016–05/31/2019

35. RUI: Exploring Nuclear Structure through Collaborative Research
Sharon Stephenson
NSF 1613429, 8/1/2016–7/31/2018

36. RUI: Collaboration to Enhance Participation of Minority and Undergraduate Students in Nuclear Science
Paul Gueye, Sharon Stephenson, Jim Brown, Nathan Frank
NSF 1713589, 1713956, 1713245, 1713522 08/15/2017–08/15/2020

37. MRI Consortium: Development of a Charged Particle Telescope by Undergraduate Research Students for Studies of Exotic Nuclei.
Nathan Frank
NSF 1827840, 2018–2020.

38. RUI: Nuclear Physics at Hope College With Undergraduates: New Science Enhancing the STEM Workforce.
Paul DeYoung
NSF 1911418, 2019–2022.

39. RUI: Experimental Research in Nuclear Astrophysics and Nuclear Structure.
Jerry Hinnefeld
NSF 1913553, 2019–2022

40. RUI: Collaboration to Enhance Participation of Minority and Undergraduate Students in Nuclear Science
Paul Gueye
NSF 19364040, 2019–2020

41. Collaborative Research: RUI: Study of Exotic Nuclei and Neutron Detector Response
Anthony Kuchera
NSF 2011398, 2020–2023

42. Catalyst Award: Nuclear Science at Virginia State University, Building Connections to FRIB Science
Thomas Redpath
NSF 2100969, 2021–2023

43. Machine learning methods for analyzing multi-neutron decay measurements
Thomas Redpath
DoE DE-SC0022037

44. RUI: Nuclear Science with Undergraduate Reserchers: Studies of Nuclei at the Extremes and New Applications of Nuclear Techniques
Paul A. DeYoung and Belen Monteagudo Godoy
NSF PHY-2209138, 2022-2025

45. RUI: Supporting New Efforts in Studies of Neutron-Rich Nuclides.
Nathan Frank
NSF PHY-2011265, 2020-2024

46. Collaborative: RUI: Study of Neutron-Rich Nuclei and Neutron Detector Response.
Anthony Kuchera and Warren Rogers
NSF PHY-2311125, 2023-2026

8.9 NSCL/FRIB Faculty Grants

1. MSU/FSU Consortium Development of a Compact Sweeper Magnet for Neutron Coincidence Experiments at the NSCL
   Michael Thoennessen (Principal Investigator); Kirby Kemper, Steven Van Sciver, Gregers Hansen, Bradley Sherrill (Co-Principal Investigators)
   NSF 9871462, 1998–2003

2. MRI: MSU/FSU Consortium to Develop a Highly Efficient Neutron Detector Array to Study Neutron-Rich Rare Isotopes at the NSCL
   Michael Thoennessen (Principal Investigator); Kirby Kemper, Samuel Tabor, Gregers Hansen, Thomas Baumann (Co-Principal Investigators)
   NSF 0132434, 2001–2004

3. Windows on the Universe: Study of Open Quantum Systems in Atomic Nuclei
   Paul Gueye (Principal Investigator), Bradley Sherrill (Co-Principal Investigator), Thomas Baumann (Co-Principal Investigator), Wolfgang Mittig (Co-Principal Investigator), Oleg Tarasov (Co-Principal Investigator)
   NSF 2012040, 2020–2023

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