**Open nuclear systems in structure and astrophysics**

I. Wiedenhöver, Physics Department, Florida State University, Tallahassee, Florida 32306, USA

The John D. Fox Laboratory at Florida State University operates a 9 MV Tandem + 8 MV superconducting linear accelerator system, which is used for research in nuclear structure, reactions and nuclear astrophysics by the group of six local scientists, their students and and a growing number of outside collaborators. The laboratory houses a lineup of updated experimental devices, including the most recently installed 16-Clover Clarion-2 [1] array for high-resolution gamma spectroscopy, which was built and is operated at FSU in collaboration with Oak Ridge National Laboratory. The second prominent device is a large-acceptance high-resolution magnetic spectrograph called SE-SPS for which two ancillary devices were developed, the SABRE [2] silicon detector array for resonance spectroscopy and the CeBrA scintillator array [3] for coincident reaction-gamma spectroscopy. Finally, the Resolut in-flight radioactive beam facility is used to provide beams one- or two nucleons off stability for research in nuclear astrophysics and nuclear structure of exotic nuclei[4], with the Anasen[5] and Encore[6] active-target detectors.

A research focus on the physics of unbound nuclear states has developed at the laboratory, carried out in experiments with the magnetic spectrograph and the radioactive beam facility. A prominent example lies the confirmation and characterization of a proton-resonance in $^{11}$B. The existence of this resonance had been proposed as a doorway to explain the observation of a beta-delayed proton-decay in the neutron-rich nucleus $^{11}$Be[7,8]. In experiments at the FSU radioactive beam facility this resonance was populated with the proton-transfer reaction $^{10}$Be(d,n)$^{11}$B and its surprisingly strong single-proton character was established [9]. This is understood as a consequence of the interactions with the proton-continuum, in effect concentrating the proton strength near the emission threshold. Additional experiments with the spectrograph established an upper limit of alpha-decay from the same resonance, confirming this interpretation. Another line of investigation addresses the mixing of unbound states through the continuum, studied in the spectrum of the first two $3/2^+$ resonances in $^{13}$N and $^{13}$C. Detailed experiments on the decay angular correlations were performed and used to characterize the angular momentum content of continuum interactions. We believe that a better understanding of the role of continuum on the spectrum of resonances is an important contribution to the physics of the most exotic nuclei.

This work was supported by NSF under grants PHY-2012522 and PHY-2412808

[1] T. Gray *et al.: CLARION2-TRINITY: A Compton-suppressed HPGe and GAGG:Ce-Si-Si array for absolute cross-section measurements with heavy ions,* NIM A 1041, 167392 (2022)
[2] E. Good *et al.: SABRE: The Silicon Array for Branching Ratio Experiments*, NIM A 1003,165302 (2021)
[3] A. Conley *et al.: The CeBrA demonstrator for particle-gamma coincidence experiments at the FSU Super-Enge Split-Pole Spectrograph,* NIM A 1058,168827 (2024)
[4] I. Wiedenhöver, L.T. Baby *et al.: Studies of Exotic Nuclei at the RESOLUT Facility of Florida State University,* Proceedings of the 5th International Conference on "Fission and properties of neutron-rich nuclei" (ICFN5) 144-151 (2014), World Scientific.
[5] E. Koshchiy, J.C. Blackmon, G.V. Rogachev, I. Wiedenhöver *et al.: ANASEN: The array for nuclear astrophysics and structure with exotic nuclei,* NIM A 870, 1 (2017)
[6] B,W, Asher *et al., The Encore active target detector: A Multi-Sampling Ionization Chamber,* NIM A 1014, 165724 (2021)
[7] K. Riisager, O. Forstner, M. Borge, J. Briz, M. Carmona-Gallardo, L. Fraile, H. Fynbo, T. Giles, A.

Gottberg, and A. Heinz et al., *$^{11}$Be(beta-p), a quasi-free neutron decay?*, Phys. Lett. B 732, 305 (2014)
[8] Y. Ayyad et al., *Direct Observation of Proton Emission in $^{11}$Be* , Phys. Rev. Lett. 123, 082501 (2019)
[9] Eilens E. Lopez-Saavedra, S. Almaraz-Calderon, *et al.*: *Observation of a Near-Threshold Proton Resonance in $^{11}$B,* Phys. Rev. Lett. 129, 012502 (2022)