

# Executive Summary of workshop on: Opportunities with Neutron Induced Reactions

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*Authored by the workshop participants*

This White Paper reports on a virtual meeting held 17-18 October 2022 on “Opportunities with Neutron Induced Reactions”, held as a pre-meeting in preparation for the Nuclear Structure, Reactions, and Astrophysics Town Hall. There were 55 virtual participants for the meeting, which consisted of contributed presentations followed by substantial discussion time. There were 16 formal presentations as well as several shorter, less formal concept discussions.

What clearly emerged over the course of the meeting was that there have been significant advances over the last decade in experimental capability, both in facility advances *and* in enhanced measurement fidelity and selectivity. Neutron beam intensities have increased by orders of magnitude while simultaneously improving in resolution. Advanced detector systems enable measurement with high resolution, on trace or short-lived samples, and of previously inaccessible processes.

The scientific need for these capabilities continues to grow. Theoretical advances have revealed that individual neutron-induced reactions on unstable isotopes play a far more significant role in the origins of the heavy elements than previously realized. Neutrons offer a unique, low-angular momentum probe of nuclear structure and fission properties, and new capabilities are expanding those measurements to unstable isotopes where little is known.

Further, the scientific relevance of neutron beams has expanded well beyond the traditional nuclear physics disciplines of nuclear astrophysics, reactions, and structure. These facilities and techniques have opened new fields of study in fields such as isotope science, environmental studies, and national security, just to name a few. These new applications are attracting a workforce broader than that traditionally inclined to pursue nuclear physics. The disparate laboratories enable hands-on experience and local engagement with neutron studies and offer a doorway to the broader nuclear physics questions.

Finally, new concepts about how to perform measurement offer a revolution in what is experimentally possible for direct measurements.

The participants unanimously agreed to the following three Resolutions.

**Resolution I:** The study of neutron-induced reactions offers an essential window into atomic nuclei, elucidating physics ranging from the origin of the elements to the structure and decay of nuclear levels, to testing nuclear models ranging from *ab initio* theory of light ion reactions to mean-field treatment of many-body processes through fission. New high flux neutron facilities and sophisticated detector technologies throughout the world enable unprecedented

investigation into the properties of nuclei. These unique, key studies complement charged particle studies across the chart of nuclides. We strongly support funding of research and infrastructure taking advantage of the new opportunities enabled by advances in facilities and instrumentation.

**Resolution II:** The concept of a neutron target facility, where an energetic ion beam passes through and reacts with a standing field of thermalized neutrons, would offer a transformational change in the experimental reach for direct neutron-induced reaction measurements. First investigations of the feasibility of such a concept are being undertaken. We strongly support leveraging these initial studies to pursue transformational scientific opportunities should they arise.

**Resolution III:** Neutron-induced reaction studies support a varied set of societal applications spanning space science, non-proliferation, nuclear energy, stockpile stewardship, isotope production, cultural heritage, environmental studies, and many others. This broad pool of applications brings nuclear physics in contact with aspects of everyday life throughout a changing world. This fosters a diverse work environment and develops a versatile workforce, to the betterment of the field and society at large. We strongly support further engaging in this diverse model of communities, facilities, funding, and workforce.