



U.S. DEPARTMENT OF
ENERGY

Office of
Science

Neutron Subcommittee Update

BES Advisory Committee Meeting

July 11, 2019

Marc Kastner, Chair
Basic Energy Sciences Advisory Committee

BESAC Neutron Subcommittee

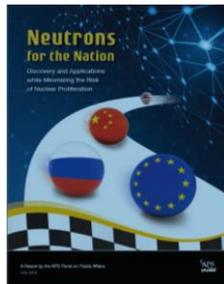
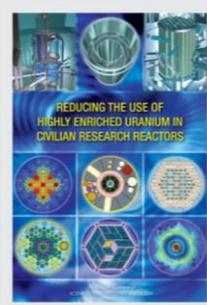
- Background of the study
- Charge and framing questions
- Study scope
- Subcommittee members
- Subcommittee activities



Neutron Subcommittee Charge

Background

- ORNL's High Flux Isotope Reactor (HFIR) was completed in 1965
 - **Designed for isotope production**
 - **Equipped for neutron scattering – small-sample research**
 - **Materials: irradiation and neutron activation analysis**
- No high-performance research reactor commissioned in the U.S. since 1967
 - INL's Versatile Test Reactor (at CD-0) to address large engineering studies
- Academies report (2016): **Reducing the Use of Highly Enriched Uranium in Civilian Research Reactors** – conversion to low enriched uranium (LEU) fuel
- American Physical Society Panel on Public Affairs (APS POPA) report (2018): **Neutrons for the Nation** – reduce proliferation risk while keeping neutrons available for science and industry



- **BESAC Neutron Subcommittee Charge** (March 3, 2019):
 - Assess the **scientific justification** for a domestic high-performance reactor-based research facility



New BESAC Charge from Dr. Binkley (March 3, 2019)

The U.S. Department of Energy (DOE) has maintained long-term stewardship of neutron capabilities for the Nation. *The combination of the Spallation Neutron Source (SNS) and the High Flux Isotope Reactor (HFIR), under the auspices of Basic Energy Sciences (BES) in the Office of Science, has provided the U.S. scientific community with leading neutron capabilities in support of DOE's missions in science, energy, environment, and national security. With the planning process for both the PPU and STS projects under way in 2019, I am writing to seek the input of BESAC on the long-term strategy concerning HFIR, which complements SNS and is among the highest-flux reactor-based sources in the world. With HFIR entering its 6th decade, its long-term future requires careful thought and planning, especially in the context of the U.S. domestic high-performance neutron research facilities.*

This charge is also in part informed by the 2018 "Neutrons for the Nation" report, commissioned by the American Physical Society's Panel on Public Affairs, which focuses on the competing goals of reducing nuclear proliferation risk while maintaining intense controlled sources of neutrons for vital scientific and industrial work. The report highlighted the continued need for the U.S. to support its diversity of neutron R&D capabilities, as well as to initiate planning for a new generation of high-performance research reactors.



New BESAC Charge from Dr. Binkley (March 3, 2019)

I am asking BESAC to form a subcommittee to assess *the scientific justification for a U.S. domestic high-performance reactor-based research facility*, taking into account current international plans and existing domestic facility infrastructure.

- *What is the merit and significance of the science that could be addressed by a high performance, steady-state reactor, and what is its importance in the overall context of research in materials sciences and related disciplines?*
- *What are the capabilities of other domestic and international facilities, existing and planned, to address the science opportunities afforded by such a domestic research reactor?*
- *What are the benefits to other fields of science and technology and to industry of establishing such a capability in the U.S.? In particular, consider applications such as isotope production, materials irradiation, neutron imaging, dark matter research, and neutron activation for trace element analysis.*
- *What are the strengths and limitations of a steady-state research reactor compared to a pulsed spallation neutron source for science, engineering, and technology?*
- *Are there feasible upgrade paths for HFIR to provide world-leading capabilities in serving the Office of Science missions well into the future?*
- *Can Low Enriched Uranium (LEU) and High Assay LEU (HALEU) fuels (defined as <20% enriched U-235) replace Highly Enriched Uranium fuels in research reactors while preserving the needed characteristics of neutrons produced by steady-state reactors? What R&D would be needed to support LEU and HALEU fuels development?*



Neutron Subcommittee Charge

Framing Questions in Charge Letter

- **Science case:** Significance in overall context of research in relevant disciplines
- **Other facilities:** Domestic and foreign, that could address the science case
- **Applications:** Isotope production, materials irradiation, neutron imaging, dark matter, neutron activation for trace element analysis
- **Spallation sources:** Strengths, limitations, capabilities relative to research reactors
- **HFIR upgrade paths:** For world leadership in reactor-based sources
- **Fuels development:** Replacing Highly Enriched Uranium (HEU) with LEU and High Assay LEU (HALEU), for non-proliferation

Neutron Subcommittee Charge

Scope of the Study

- **Overall:** Comprehensively cover the wide range of topics
- **Expertise:** Communities go beyond BESAC and BES. Reach out to:
 - NP Isotope Program – isotope production
 - Nuclear materials irradiation experts
 - NIST Center for Neutron Research (NCNR)
 - International experts and facilities
 - Other advisory committees (ACs):
Nuclear Science (NSAC), Fusion Energy Science (FESAC),
Defense Programs (DPAC), Nuclear Energy (NEAC)
- **Topics:** Neutron scattering, soft condensed matter, structural materials, theoretical physics, particle physics / neutrinos, fuels, reactor technology and R&D, uranium fuel (LEU) conversion for research reactors, fuel for isotope production

Neutron Subcommittee Charge

Subcommittee Members and Areas of Expertise

| | | |
|-----------------------------|--|--|
| Robert Birgeneau, Chair | UC Berkeley | Neutron scattering |
| David Robertson, Vice Chair | U Missouri, MURR reactor | Isotope production |
| Marc Kastner, BESAC Chair | SciPhil | |
| Sue Clark | BESAC/Pacific Northwest National Lab | Environmental chemistry |
| Pengcheng Dai | Rice | Neutron scattering |
| Thomas Epps | BESAC/U Delaware | Neutron scattering, soft matter |
| Karsten Heeger | Yale | Neutrinos/particle physics |
| Bernhard Keimer | MPI-Stuttgart (Germany), FRM-II reactor | Neutron scattering |
| Despina Louca | BESAC/U Virginia | Neutron scattering |
| Pete Lyons | Nuclear Energy Advisory Committee | General nuclear energy topics |
| Allan MacDonald | BESAC/UT Austin | Theorist |
| Sean O'Kelly | Idaho National Lab | Reactor technology & R&D |
| Brad Olsen | MIT | Soft materials |
| Julia Phillips | Sandia National Labs (retired) | POPA study chair |
| Anthony Rollett | BESAC/Carnegie Mellon | structural materials; NNSA DPSC connection |
| Kate Ross | Colorado State | Neutron scattering |
| Michael Rowe | NIST Center for Neutron Research (retired) | Neutron scattering |
| John Stevens | Argonne National Lab | LEU Conversion |
| William Stirling | Institut Laue-Langevin (France) | Reactor technology & R&D |
| Brian Wirth | FESAC/U Tennessee - Knoxville | Materials under irradiation |



Neutron Subcommittee Charge

Subcommittee Activities

- **Report is due July 31, 2020**
- **Kickoff meeting** (Berkeley, August 19-20): Talks on Isotope Program, POPA report, Academies report, HFIR, SNS, European neutron sources (ILL Grenoble, FRM-II Munich, etc.), NIST NCNR, INL Advanced Test Reactor (ATR) and VTR – facility-oriented meeting
- **Workshop** (D.C. area, November 2019): Research-oriented meeting, main focus on the science needs for a next-generation reactor; include talk on national security from NA-20 (DOE NNSA Office of Defense Nuclear Nonproliferation)
- **Site visits:** ORNL (HFIR, SNS), other DOE labs (including INL), NIST NCNR (in conjunction with Nov. 2019 workshop), optional visits to international facilities (ILL, FRM-II, BR2 Belgium, ...)