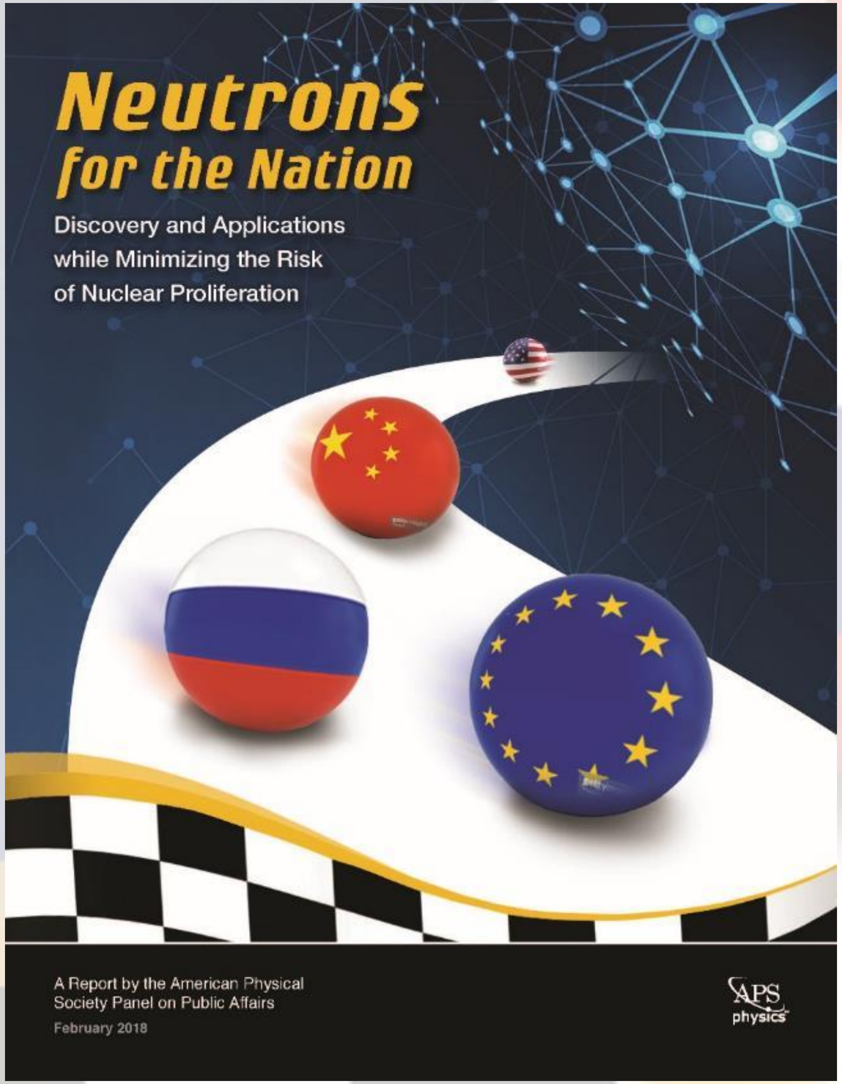
Neutrons for the Nation

A report by the APS Panel on Public Affairs



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Motivation for the report

- How important are neutron sources for science, engineering, and industry for the foreseeable future?
- What neutron source characteristics are important? How are such neutrons produced now and in the near future?
- What does the U.S. need to do to be a global player in neutron science, engineering, and applications in the coming decades?
- What policy issues need to be considered in designing and building future neutron sources?

Neutrons ARE important for science, engineering, and industry

- Neutron scattering – as one of an ensemble of techniques
- Physics of the neutron
- Materials testing
- Isotope production
- Transmutation

KEY FINDING
Investigations performed at neutron sources are essential components of R&D in numerous areas of science and engineering.

Neutron scattering is an essential component of an ensemble of research techniques

KEY FINDING
Neutron scattering is often an essential part of a broader experimental study that uses a complementary suite of tools.

- Complementary techniques:
  - Materials synthesis and “in lab” characterization
  - Light sources
  - Computational simulations
  - NMR
- Advances in instrumentation at neutron sources have dramatically increased the capabilities of the facilities

U.S. neutron R&D is vulnerable

Major neutron scattering facilities (2017)

- Significant world-wide activity in source (spallation and reactor) and instrument construction and commissioning
- Smaller facilities contribute to overall regional productivity
- US capacity (number of scattering instruments) peaked in 1996
- No HPRR has been commissioned in the U.S. in 50 years

KEY FINDING

The U.S. has lost important capability in neutron R&D in the last 2 decades and is no longer the world leader.

Need and Challenge

High performance research reactors are important for neutron research, development, and production

Uniquely or especially suited for:

- Materials testing
- Isotope production
- Capacity to support many experiments

KEY FINDING
Current high performance research reactors (fueled by HEU) provide unique R&D capabilities relative to other neutron sources available today.

*HEU – enriched ^{235}U content > 20%

U.S.-based HPRRs use highly enriched uranium fuel* (HEU)

- HEU constitutes a proliferation risk.
- U.S. policy dictates eliminating HEU in civilian applications wherever possible.
- Converting existing U.S. HPRRs to low enriched uranium is not possible with existing fuel.

KEY FINDING
Reactor fuels containing highly enriched uranium represent a risk for proliferation, which should be considered when planning for the future infrastructure for neutron R&D.

World-class neutron R&D currently requires three things

Spallation Sources:
- Peak pulse intensity
- Time-dependent measurements
- Accelerator-based (no ^{235}U)

KEY FINDING:
World-class neutron science & engineering require the complementary capabilities of spallation facilities, research reactors, and high-performance instrumentation. While there is some overlap in the capabilities of spallation and reactor sources, each provides capabilities that cannot now be duplicated by the other type of source.

Research Reactors:
- Capacity to support many experiments
- Higher time-averaged flux
- Larger irradiation area
- Spectrum characteristics

High-performance instrumentation
- Computing & data analytics
- Beamline instrumentation

The path forward - RECOMMENDATIONS

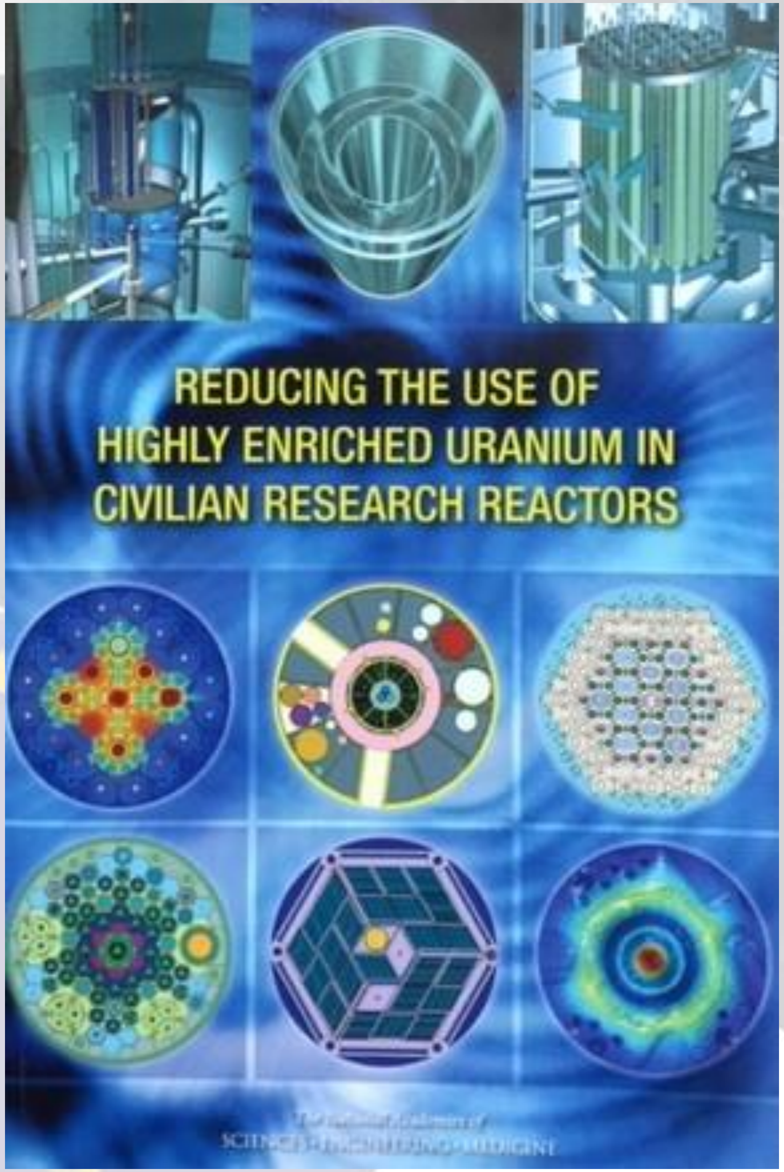
The U.S. should:

1. Continue to support a diversity of neutron R&D capabilities, including both research reactors and spallation sources

   and strike a balance between retaining/enhancing current neutron capabilities and reducing/eliminating use of HEU.
2. Sharply increase investment in neutron instrumentation development and deployment to leverage R&D capacity and capability and to complement continuing investments in complementary tools such as light sources and high-performance computing.
3. Reaffirm its commitment to the timely development and deployment of high-density LEU fuels for existing HPRRs.
4. Initiate an effort to competitively design and build a new generation of LEU-fueled HPRRs that would satisfy all needs that rely on current HPRRs.

Other considerations

- The lead time for commissioning a new HPRR (of any type) is very long.
- Development of very high density LEU fuels appropriate for converting existing HPRRs has taken MUCH longer than originally anticipated, and the timeline has moved out repeatedly.
- Can **all** of the uses of HPRRs (especially HFIR) be met without the use of HEU?
- Can/should all of the current uses of HFIR be met in an single HPRR?
- Are there other (non-HPRR-based) innovative approaches to satisfying all of the needs currently met by HEU-fueled HPRRs?



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