

Office of **NUCLEAR ENERGY**



Advanced Sensors and Instrumentation

ASI program FY25 planned activities

Advanced Sensors and Instrumentation (ASI) Annual Program Webinar November 4, 6-7, 2024

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Program roadmap based on technology gap identification

LVDTs

- **Neutron flux sensors**
- Dosimetry
- Thermocouples
- Ultrasonic thermometers
- Fiber optic distributed measurement
- Melt wires
- SiC monitors
- Fiber optic pyrometry
- Thermal conductivity probes
- Fiber optic pressure sensors
- Electro-impedance detector
- Acoustic emission detection
- **Rad-hard electronics**

The ASI program activities have been structured based on three types of applications:



Sensors for Advanced Reactors

Qualification testing and Irradiation Experiments

Sensors Integration (advanced controls)

ASI program roadmap (2023)

Optical Fiber

Program milestones and technology maturation strategy

ACTIVITIES OVERVIEW	2022	2023	2024	2025	2026	2027	2028
Flux Sensors							
Optical Fibers							
Acoustic Sensors							
Thermocouples							
Rad-hard Electronics							
LVDT							
Passive Monitors							
Material properties							
Digital Twin							
Communication							
Advanced Controls							

Development

Identification and research of needs, applications, functional requirements and complete feasibility demonstration

Testing

Performance assessment and design optimization under relevant conditions

Qualification

Demonstration through benchmarking using relevant methods and/or facilities

Deployment

Transition to end-user applications and/or commercialization partners

FY25 budget for directed research projects



- Roadmap implementation is based on available funds
- FY24 was a successful year as most program priorities have been executed
- In FY25 DOE included ASI as a budget line item for NE7 with a \$9M funding request
- Funding level will be uncertain until enacted because of chambers conflicting guidelines
- Current plan is based on a conservative target of \$4.3M

Reactor power monitoring



Sensors for Advanced Reactors

Sensors for Irradiation Experiments

Reactor power monitoring Structural Health Monitoring Optical fibers Thermometry Rad-hard electronics

Sensors Integration

Sensor qualification

Passive monitors

LVDT

Advanced controls Communication Nuclear Energy Sensors database Neutron energy spectrum unfolding methods using self-powered neutron detectors (SPND) and dosimetry calibration

R&D focus:

- Epithermal/fast energy neutrons for advanced reactors application
- Demonstration test in irradiation facilities



Optimization of Sensor Arrangements for Power Distribution Synthesis (ORNL)

R&D focus:

- Impact of time-dependent reactor physics
- MARVEL demonstration for advanced controls development

Structural Health Monitoring



Sensors for Advanced Reactors

Reactor power monitoring **Structural Health Monitoring Optical fibers** Thermometry Rad-hard electronics

Sensors for Irradiation Experiments

Sensor qualification LVDT Passive monitors

Sensors Integration

Advanced controls Communication Nuclear Energy Sensors database



R&D focus:

- Advanced manufacturing and embedding
- Accelerometer and acoustic emission sensor for fuel transient testing
- **Development of Electro Magnetic Acoustic** Transducers (EMAT) based on Magneto-Strictive (MS) materials









Printed strain gauges for high temperature applications (INL)

R&D focus:

Complete assessment after irradiation test

Optical fibers



Sensors for Advanced Reactors

Reactor power monitoring Structural Health Monitoring **Optical fibers** Thermometry Rad-hard electronics

Sensors for Irradiation Experiments

Sensor qualification LVDT Passive monitors

Sensors Integration

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Metal-Embedded Optical Fibers for Structural Health Monitoring (ORNL, INL, PNNL)

R&D focus:

- Complete work on Electric Field Assisted Sintering and Hot Confined Rolling
- Evaluate alternative methods for packaging and attachment



Fiber optic sensors nuclear applications (INL)

R&D focus:

- Pressure sensor irradiation test
- Pyrometer for steam environment



Thermometry



Sensors for Advanced Reactors

Reactor power monitoring Structural Health Monitoring Optical fibers **Thermometry** Rad-hard electronics

Sensors for Irradiation Experiments



Sensor qualification LVDT Passive monitors

Sensors Integration

Advanced controls Communication Nuclear Energy Sensors database Photo-thermal radiometry (PTR) to measure thermal conductivity of nuclear fuel and materials during irradiation (INL)

R&D focus:

Complete assessment after irradiation test



Sensor qualification



Sensors for Advanced Reactors

Reactor power monitoring Structural Health Monitoring Optical fibers Thermometry Rad-hard electronics

Sensors for Irradiation Experiments

Sensor qualification LVDT Passive monitors

Sensors Integration

Advanced controls Communication Nuclear Energy Sensors database

Instrumentation Qualification Testing (INL)

R&D focus:

 Non-nuclear testing of neutron qualification device (NQD)



General attributes:

- NIST traceable pedigree where applicable
- Closure calibrations (quantitative error analysis)
- Statistically significant number of sensors
- Essentially a "Calibration Laboratory" in a test reactor
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Passive monitors



Sensors for Advanced Reactors

Reactor power monitoring Structural Health Monitoring Optical fibers Thermometry Rad-hard electronics

Sensors for Irradiation Experiments



Sensor qualification LVDT **Passive monitors**

Sensors Integration

Advanced controls Communication Nuclear Energy Sensors database Standardization of temperature measurement during irradiation using SiC monitors (ORNL, INL)

R&D focus:

 Initial round-robin with available irradiated monitors using dilatometry





Koyanagi T, Katoh Y, Lance MJ. Raman spectroscopy of neutron irradiated silicon carbide: Correlation among Raman spectra, swelling, and irradiation temperature. *J Raman Spectrosc*. 2018; 49: 1686–1692. https://doi.org/10.1002/jrs.5425

Advanced controls



Sensors for Advanced Reactors

Reactor power monitoring Structural Health Monitoring Optical fibers Thermometry Rad-hard electronics

Sensors for Irradiation Experiments

Sensor qualification LVDT Passive monitors

Sensors Integration

Advanced controls Communication Nuclear Energy Sensors database

Advanced controls (INL, ANL)

R&D focus:

- Demonstrating a Spectrum of AI in Advanced Reactor Supervisory Control Systems
- Sensor placement optimization for advanced reactors real-time core monitoring and control (demonstration in Purdue University Reactor Number One (PUR-1))







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Thank You

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