

U.S. DOE-NE Fast Reactor Program

Bo Feng (National Technical Director)

Argonne National Laboratory

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Overview

- Program Overview
 - Origins
 - Mission
 - Organization
- Technical Area Overviews
 - Technology Development
 - Methods, Modeling, and Validation
 - Advanced Materials

Program Origins

Fast Reactor R&D History

- Argonne has a strong history in fast reactor R&D (EBR-I, EBR-II, FFTF, ALMR and IFR programs).
- IFR (Integral Fast Reactor) budget was about \$300M/y (in today's dollars) from 1984-1994.
- In 1994, all advanced reactor research and facilities were abruptly terminated, national laboratories lost significant staff, capabilities, and infrastructure.

Re-Emergence of Fast Reactor R&D

- Fast Reactor R&D re-emerged in the DOE fuel cycle programs ~2000 (e.g., GNEP, Accelerator Driven Systems, etc.)
- Priority R&D pursued in DOE advanced reactor programs after ~2010
- In 2015, Fast Reactor and HTGR R&D merged into DOE Advanced Reactor Technologies (ART), MSR added in 2018, Micro Reactor Program (MRP) in 2019. In 2022, the DOE fast reactor R&D portfolio was rebranded as the “Fast Reactor Program” (FRP).



Experimental Breeder Reactor-II (EBR-II)

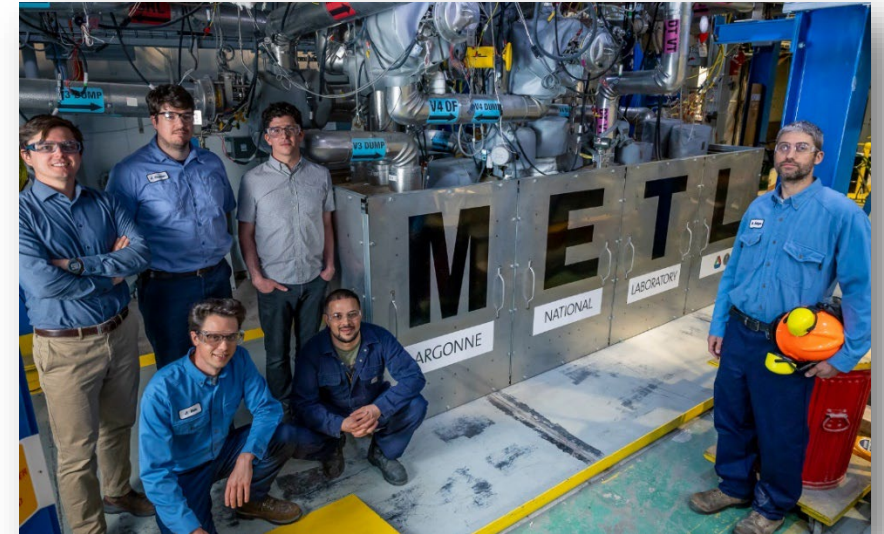
Program Origins

Emergence of U.S. Advanced Reactor Industry

- DOE ARC13 and ARC14 awards on specific industry R&D topics (2013-2014)
- Larger ARC15 awards on concept technology development – X-energy, MCFR
- Technology Working Groups formed in 2017 to advise DOE R&D Program; about 10 vendors formed the Fast Reactor Working Group
- DOE Advanced Reactor Demonstration Projects and ARC-20 Awards (including ARC Clean Technology award) funded in 2020 budget

Significant Recent Engineering Experience:

- ARC Clean Technology
- WEC LFR design optimization
- Versatile Test Reactor
- PGSFR (South Korea)
- JAEA SFR Demo (Japan)
- ARDP Sodium



Mechanisms Engineering Test Loop (METL) team

Program Leadership



Kat Abbott (DOE-NE)
Program Manager



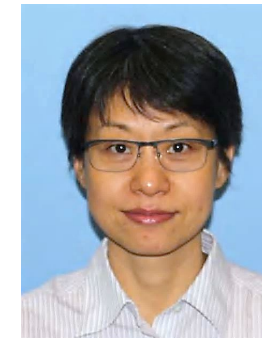
Bo Feng (ANL)
National Technical Director



Chris Grandy (ANL)
Technology Development
Technical Area Lead



Acacia Brunett (ANL)
Methods, Modeling, and Validation
Technical Area Lead



Yanli Wang (ORNL)
Advanced Materials
Technical Area Lead

Program Mission Statement and Priorities

Mission Statement

“Anticipate, confirm, and develop the technical elements needed by industry to enable and sustain successful large-scale commercialization of fast reactors”

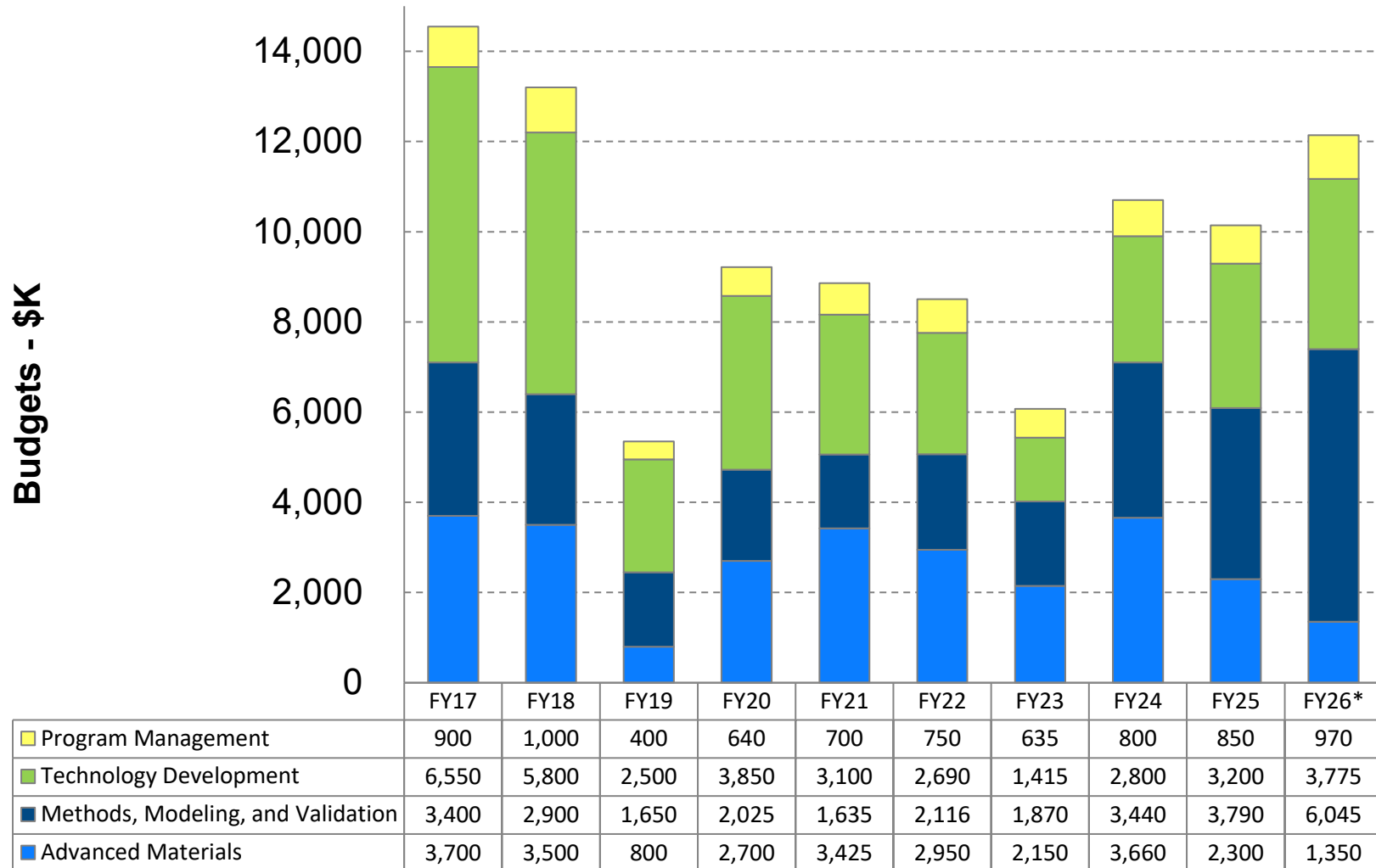
For commercial deployment of fast reactors, stakeholders have identified two recurring needs:

- Addressing technical challenges to [reduce capital costs](#) and improve economic competitiveness
- Providing validated experimental and operational data [supporting fast reactor licensing](#) cases

High-priority R&D areas:

- **Technology Development:** Sodium experiments in METL, component design and testing
- **Methods, Modeling, and Validation:** Safety and physics software and legacy fast reactor databases
- **Advanced Materials:** ASME code qualification of Alloy 709 for structural materials (100,000-h code case)

Historical Program Budgets



Technology Development

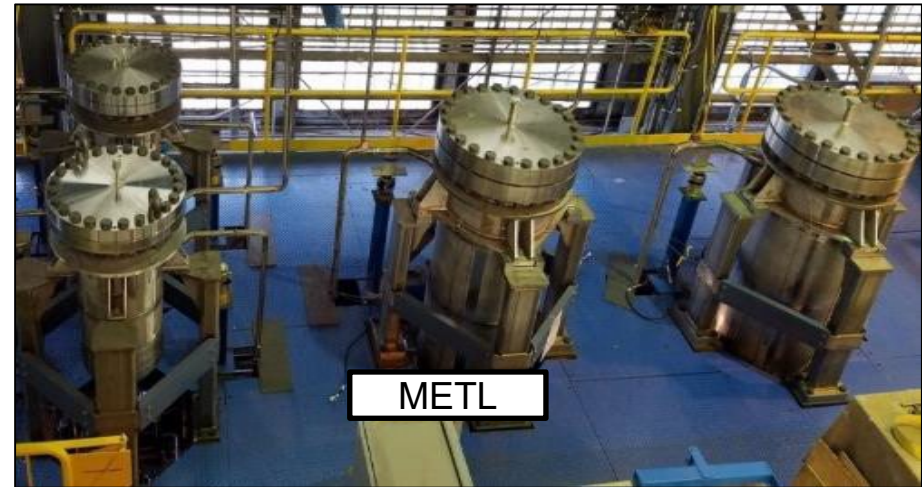
Focuses on designing, fabricating, and testing fast reactor component technologies and experiments in the Mechanisms Engineering Test Loop (METL):

- Gear Test Assembly (GTA)
- Thermal Hydraulic Experimental Test Article (THETA)
- Gripper Test Article (GrTA)
- Flow Sensor Test Article (F-STAr)
- Bearing Test Article (BTA)



These test articles either enable cost reductions and improved performance in SFRs or provide valuable experimental data under sodium for software validation, sensor design, etc.

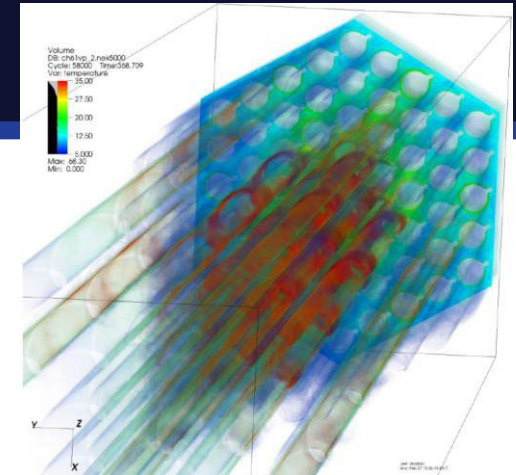
Another focus is on knowledge preservation:

- Recovering, digitizing, and preserving fast reactor and liquid metal technology information from various sources including OSTI
- Development of series of FFTF Lessons Learned Reports



Methods, Modeling, and Validation

- Verification and Validation of Fast Reactor Software (first generation)
 - Domestic and International fast reactor benchmarks (IAEA, GIF, bilateral agreements)
 - Examples: SAS4A/SASSYS-1 (systems/safety) and MFUEL (metallic fuel performance), DIF3D/REBUS (neutronics and fuel management), SRT (source term), SPCA-ANL (Na fire), NUBOW (core bowing), etc.
- Collect, organize, and perform quality assurance on fast reactor databases <https://frdb.ne.anl.gov/>
 - EBR-II Shutdown Heat Removal Test (SHRT) database (ETTD)
 - FFTF Passive Safety Testing database
 - TREAT Test Database (TREXR)
 - Fuels Irradiation & Physics Database (FIPD)   Advanced Fuels Campaign
 - Out-of-Pile Transient Test Database (OPTD)
 - Fast Reactor Reliability Database (NaSCoRD)
 - Zero Power Reactor Database (ZPRD)
- Industry needs for data and software quality assurance is growing as more license applications are underway



Nek5000 CFD simulation of flow in non-uniformly heated 61-pin assembly

FIPD: Metallic Fuels Irradiation & Physics Database

FIPD is an organized collection of metallic fuel test pin data and documentation. The database includes pin operation conditions calculated using a collection of ANL analysis codes developed during the IFR program, including axial distributions for power, temperatures, fluences, burnup, and isotopic densities. The database also contains pin measured data from post-irradiation examination, including pin fission gas release and gas chemistry measurements, and axial distributions from profilometry, gamma scans, and neutron radiography. There is also an extensive collection of documents associated with different pins and experiments, including raw PIE data, design descriptions, safety analysis, and operational reports.



Experiment Operating Data

Browse experiment operational data:

- Experiments
- Subassemblies
- Runs
- Pin Designs
- Reactor Power/Fission Gas History
- Subassembly Coolant Flow Rates



Digitized PIE Collection

Browse digitized PIE by type:

- Gas Release
- Gas Chemistry
- Irradiated Length
- Irradiated Weight
- Contact Profilometry
- Laser Profilometry
- Gamma Scan
- Neutron Radiography



Document Library

Browse documents by type and content:

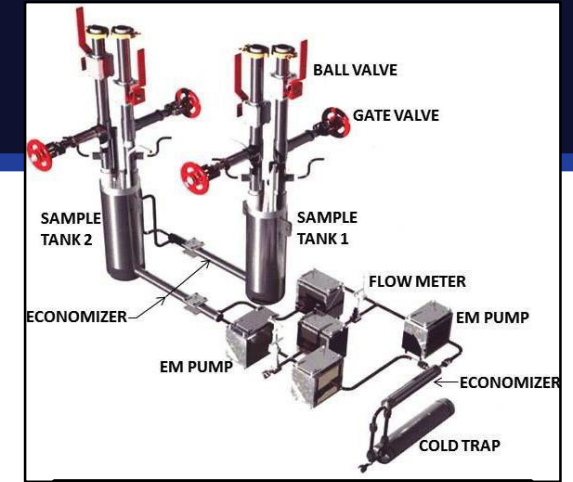
- Content Types **13**
- Document Types **11**
- Posttest Examinations **17**
- Fabrications **10**
- Authors **25**
- Open Literature Resources

Advanced Materials

- Code qualifying Alloy 709 to replace 316H stainless steel for SFR structural materials
- Higher creep strength of Alloy 709 can result in decrease in capital cost and increase in safety margins
- R&D effort is planned to accelerate Code qualification timeline by developing technical basis for increasing the time extrapolation of creep rupture data from a factor of 5X to 10X or larger
- Quantify effect of Sodium Exposure on Tensile Strength of Alloy 709 and 316H Stainless Steel in material test loops
- Future: potential examination of impact of neutron irradiation



3rd heat of A709



Sodium Material Test Loop



Creep test frames

Same Starting Point

4-Year mechanical properties and creep testing	100,000-hour ASME, Section III, Division 5 Code Case (Data package ready by Dec. 2024)
7-year limited creep testing	300,000-hour Division 5 Code Case
11-year selective creep testing	500,000-hour Division 5 Code Case

University-led R&D

Fiscal Year Funding	Project FY-ID	Title	Organization	PI First Name	PI Last Name
2018	18-15471	Integral Experimental Investigation of Radioisotope Retention in Flowing Lead for the Mechanistic Source Term Evaluation of LFR	University of New Mexico	Osman	Anderoglu
2019	19-16754	Simultaneous Corrosion/Irradiation Testing in Lead and Lead-Bismuth Eutectic: The Radiation Decelerated Corrosion Hypothesis	Massachusetts Institute of Technology	Michael	Short
2019	19-16811	Liquid metal-cooled fast reactor instrumentation technology development	University of Wisconsin-Madison	Mark	Anderson
2019	19-17355	Development of Versatile Liquid Metal Testing Facility for Lead-cooled Fast Reactor Technology	University of Pittsburgh	Jung-Kun	Lee
2020	20-19524	Non-Intrusive Flow Monitoring for Liquid Metal and Molten Salt-Cooled Reactors	Virginia Polytechnic Institute and State University	Gary	Pickrell
2021	21-24162	Self-powered wireless sensor system for health monitoring of liquid-sodium cooled fast reactors	University of Notre Dame	Yanliang	Zhang
2021	21-24389	High Temperature Electromagnetic Acoustic (EMAT) Transducers for Structural Health Monitoring	University of Cincinnati	Joseph	Corcoran
2022	22-27082	Dual Mode High Temperature MEMS Ultrasonic Sensor for Structural Health Monitoring of Liquid Metal Reactor	University of Illinois at Chicago	Didem	Ozevin
2022	22-26857	Characterizing Fast Reactor Failure Mode through Separate Effect and Prototypic Tests	Oregon State University	Guillaume	Mignot
2023	23-29603	Optical Sensors for Impurity Measurement in Liquid Metal-cooled Fast Reactors (IC-1 program)	University of Michigan	Milos	Burger
2024	24-31644	Experimental Study and Computational Modeling of P-LOFC and DLOFC Accidents in the Fast Modular Reactor Consisting of Silicon Carbide Composite Rods	University of Michigan	Xiaodong	Sun

Additional Information

- Fast Reactor Physics: <https://www.energy.gov/ne/articles/nuclear-101-what-fast-reactor>
- FRP website: <https://www.anl.gov/nse/frp>
- FRP/Industry collaboration articles:
 - <https://www.anl.gov/article/fast-reactor-technology-is-an-american-clean-green-and-secure-energy-option>
 - <https://www.anl.gov/article/argonne-and-industry-collaborate-to-shape-nuclears-future>
- METL facility website: <https://www.anl.gov/nse/metl>
- Test Article News:
 - <https://www.energy.gov/ne/articles/argonne-adds-new-testing-capability-liquid-metal-fast-reactors>
 - <https://www.anl.gov/article/argonnes-nuclear-energy-research-drives-innovation-in-geniv-reactor-safety-and-efficiency>
- Fast Reactor databases: <https://frdb.ne.anl.gov/>

Fast Reactor Program

The DOE-NE Fast Reactor Program leverages laboratory capabilities, infrastructure, and experience to conduct R&D that supports fast reactor deployment.



The Fast Reactor Program's mission is to anticipate, confirm, and develop the technical elements needed by industry to enable and sustain successful large-scale commercialization of the program is managed as part of the Department of Energy - Office of Nuclear Energy Advanced Reactor Technologies (ART) portfolio. The program's R&D is led by the national laboratories and leverages the capabilities, data, and infrastructure that have been accumulated over decades of experience involving the design, construction, and operation of multiple fast reactor experiments.

Stakeholders have identified two recurring needs for commercial deployment of fast reactors

- Address technical challenges to reduce capital costs and improve economic competitiveness
- Provide validated experimental and operational data supporting fast reactor licensing

To address these needs, the program focuses on high-priority R&D

Nuclear 101: What is a Fast Reactor?

Fast reactors use fast-moving neutrons to make better use of nuclear fuel and offer several advantages over water-cooled commercial reactors.

Office of Nuclear Energy

August 20, 2025

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BY KRISTEN MALLY DEAN | NOVEMBER 13, 2023

Companies in the nuclear industry work closely with national labs and the DOE Fast Reactor Program to develop next-generation nuclear reactors.

Nuclear fission — the energy-producing phenomena that happens when an atom splits and produces energy — has been happening safely and efficiently inside U.S. nuclear reactors for decades. These reactors, which are all water-cooled, produce clean, green power through use of a basic approach: Initiate and control a fission chain reaction and use the resulting energy to power turbines that make electricity.



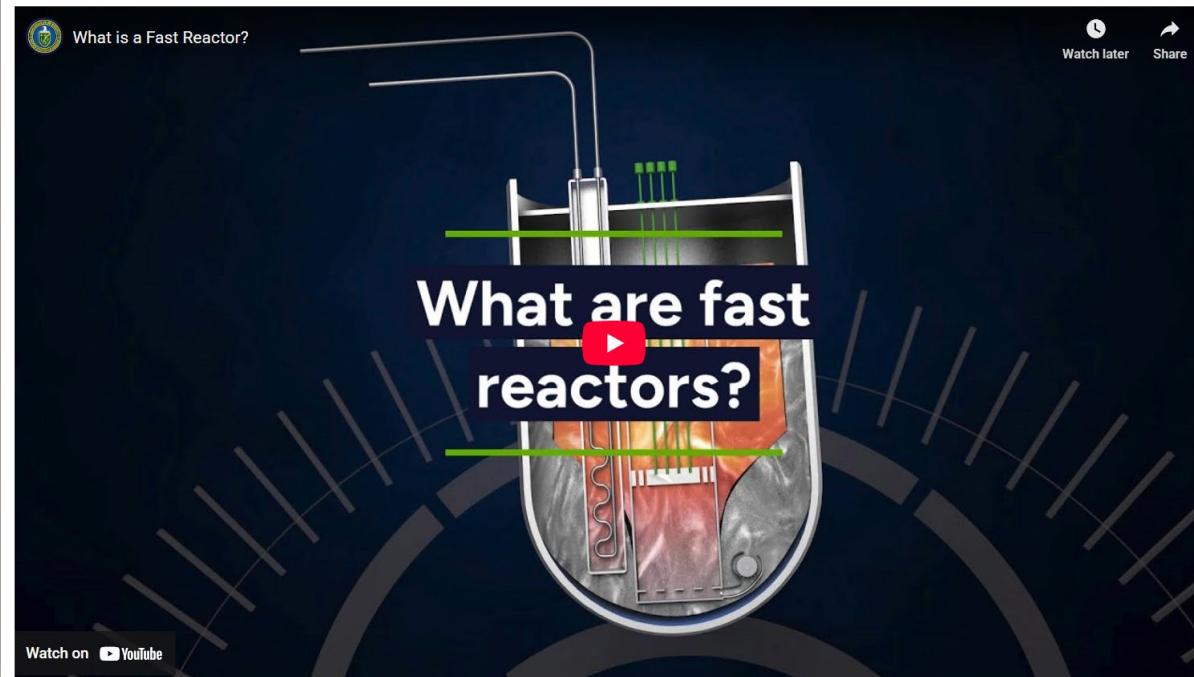
Bo Feng, national technical director of DOE-NE's Fast Reactor Program and manager of Argonne's Reactor and Fuel Cycle Analysis Group, discusses research with engineers in the METL facility. (Image by [unintelligible])



What Are Fast Reactors?

<https://www.energy.gov/ne/articles/nuclear-101-what-fast-reactor>

How Fast Reactors Work



Summary

- The Fast Reactor Program continues to successfully leverage national laboratory expertise and infrastructure to develop products that support commercialization of fast reactors in the areas of:
 - Fast reactor component design and testing, sodium experiments by leveraging the METL facility
 - Fast reactor software and databases that incorporate decades of investments in fast reactors that were designed, built, and operated
 - Fast reactor advanced materials that will significantly reduce capital costs
- At the same time, we understand the need to maintain strong interconnections and collaborations with academia, industry, and regulators.
- We have an amazing team of dedicated laboratory staff (ANL, INL, ORNL, PNNL, SNL) who are incredibly passionate about this technology and want to help deploy fast reactors.



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