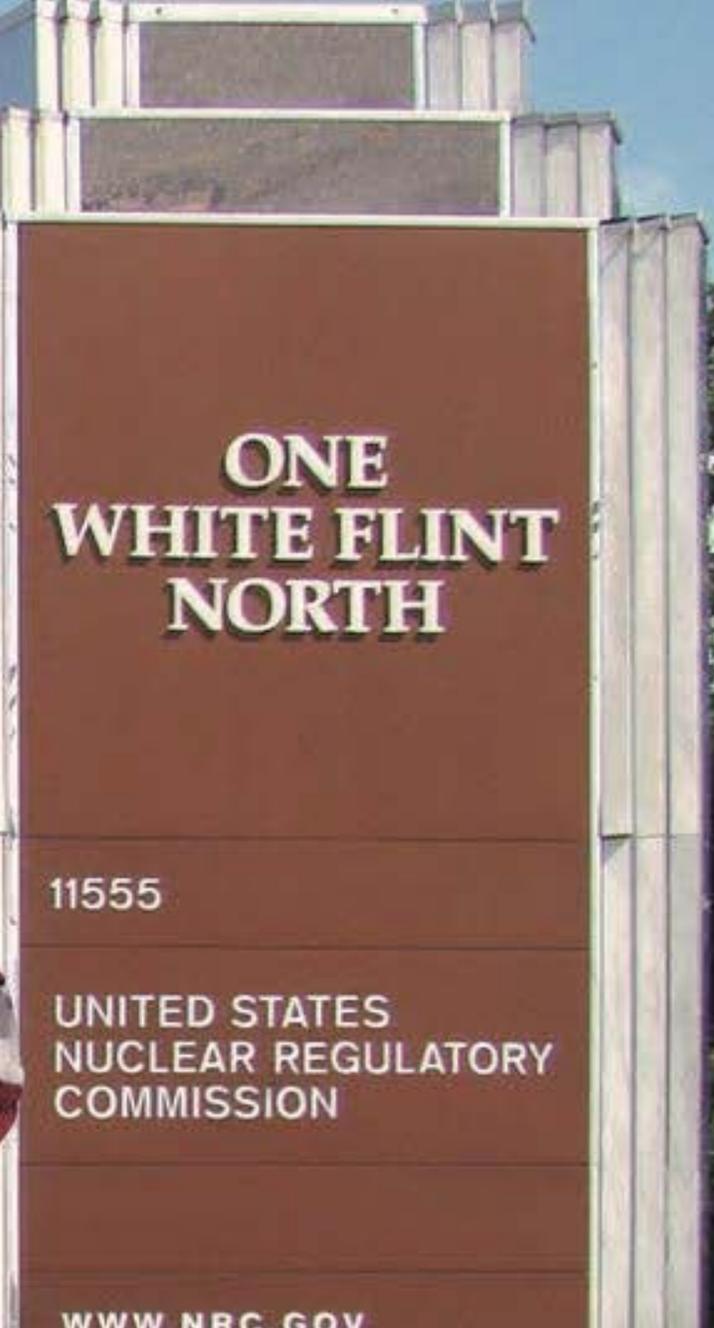




# Overview of Accident Tolerant Fuel Activities

January 24, 2023



ONE  
WHITE FLINT  
NORTH

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UNITED STATES  
NUCLEAR REGULATORY  
COMMISSION

[WWW.NRC.GOV](http://WWW.NRC.GOV)

# Speakers

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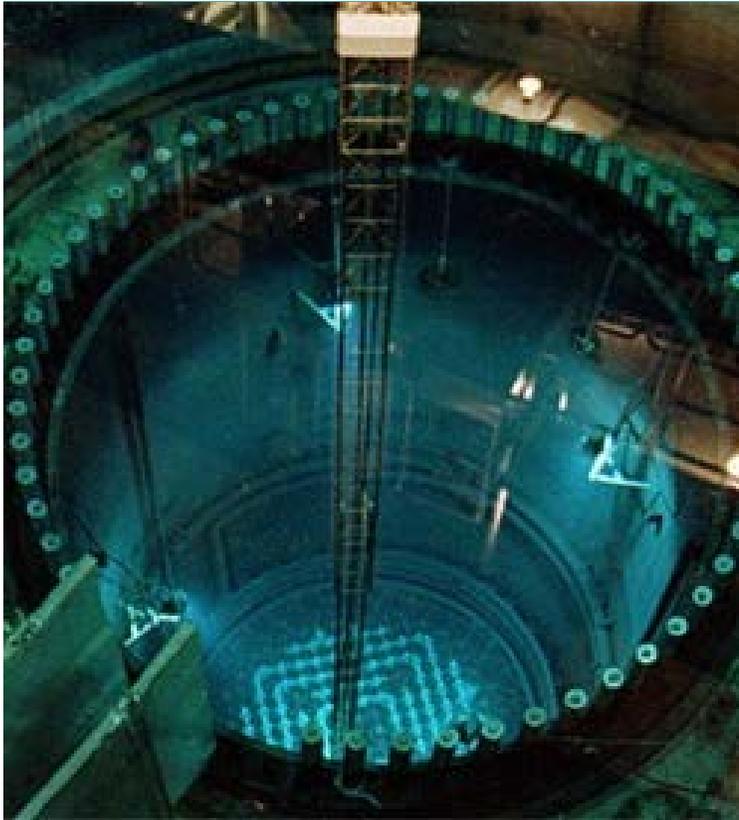
**Andrea Kock (She/Her/Hers)**, Deputy Office Director for Engineering, Office of Nuclear Reactor Regulation: Strategic overview of the NRC's ATF activities

**Kevin Heller (He/Him/His)**, Nuclear Engineer, Office of Nuclear Reactor Regulation: Licensing, engagement, and collaboration efforts for ATF

**Damaris Marcano (She/Her/Hers)**, Chief, Containment, Thermal, Chemical and Fire Protection Branch, Office of Nuclear Material Safety and Safeguards: Licensing and oversight of the enrichment, fabrication, transportation, and storage of ATF

**James Corson (He/Him/His)**, Senior Reactor Systems Engineer, Office of Nuclear Regulatory Research: Confirmatory analysis tools and international research collaboration activities

**Alice Chung (She/Her/Hers)**, Reactor Systems Engineer, Office of Nuclear Regulatory Research: Modernizing and enhancing staff expertise and tools



Andrea Kock, Deputy Office Director for Engineering, Office of Nuclear Reactor Regulation

## Strategic overview of the NRC's ATF activities

# Actively monitoring the ATF landscape

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## NEAR-TERM ATF TECHNOLOGIES

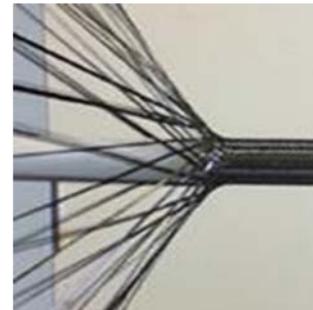


Coated Cladding



Doped Pellets

## LONGER-TERM ATF TECHNOLOGIES



Silicon Carbide  
Cladding



High Density Pellets



Extruded Metallic  
Fuel

# Significant progress in preparing for and reviewing ATF licensing actions

2020

- Guidance on chromium-coated cladding
- Transportation package for coated cladding and doped pellets with increased enrichment (IE)
- Transportation package for FeCrAl lead test assemblies
- Amendment for transportation of irradiated ATF
- High Burn-up (HBU) Topical Report
- PIRT on HBU, IE, Severe Accidents

2022

- Industry licensing expectations letter
- Regulatory framework applicability assessment
- Topical report on doped pellets
- Accepted two license amendments for ATF with IE and HBU
- Three IE licensing actions for enrichment facilities and fuel fabricators

2021

- Research information letter on FFRD
- IE rulemaking plan
- ATF project plan version 1.2
- IE topical report
- Coated cladding topical report

2023

- NUREG on environmental evaluation
- RG 1.183 Rev. 1 on source terms
- ATF regulatory issues summary
- IE rulemaking regulatory basis



Applying risk  
insights in  
decision making

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# Ensuring appropriate expertise



## Accident Tolerant Fuel Regulatory Activities

WHY GOVERNED? [NRC](#) ADDITIONAL FORGS [REFERENCES](#)

### What is Accident Tolerant Fuel?

Accident Tolerant Fuel (ATF) is a set of new technologies that lower the probability of release of radioactive materials from a reactor core during normal operations, transient conditions, and accident scenarios.

On January 11, 2018, the President signed the Nuclear Energy Innovation and Modernization Act (NEIMA), Section 107, "Commission Report On Accident Tolerant Fuel" which provides a definition of ATF as a new technology that:

- (1) make an existing commercial nuclear reactor more resilient to a nuclear incident (as defined in section 11 of the Atomic Energy Act of 1954 (42 U.S.C. 2014)) and
- (2) lower the cost of electricity over the licensed lifetime of an existing commercial nuclear reactor.

### Why the interest now?



### What is the NRC's Role?

The NRC's role with ATF is to review the new fuel technologies and their associated enrichment, fabrication, transportation, and storage aspects to ensure that they maintain public health and safety when implemented by NRC licensees.

The NRC reviews the technologies against all applicable guidance, available data, and past precedent applications to determine if the new fuel design continues to meet the NRC's regulatory requirements.

[View the NRC's role in ATF](#)

### Accident Tolerant Fuel Technologies

 Coated Cladding	 Coated Pellets	 TaCl <sub>5</sub> Cladding
 Increased Enrichment	 Uplex Burnup	 Longer Term Technologies

### Reviewing Accident Tolerant Fuel

 NRC	 Fuel Cycle, Transportation, and Storage	 Production, Site Assessment	 Independent Calculations
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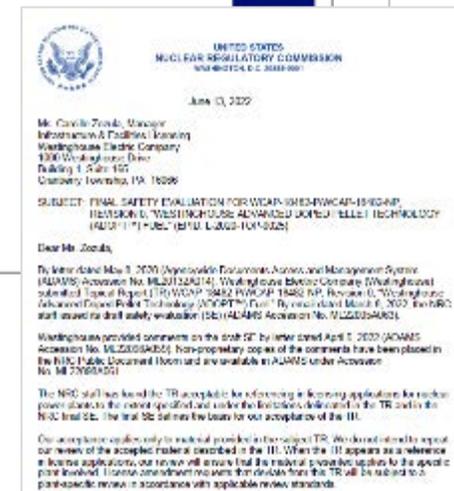
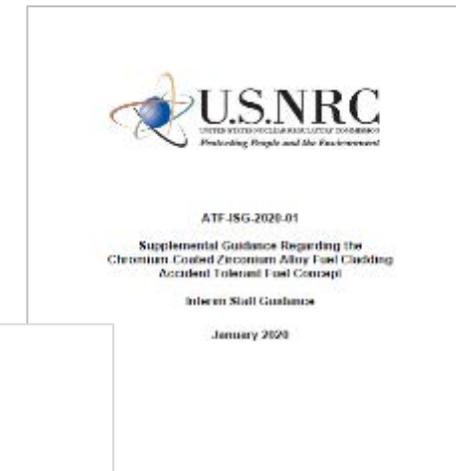
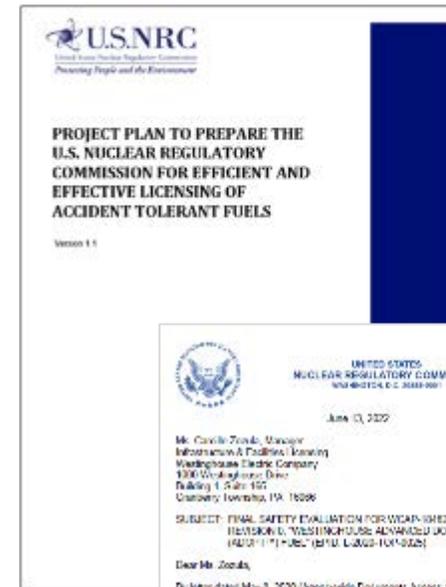


Kevin Heller, Nuclear Engineer, Office of Nuclear Reactor Regulation

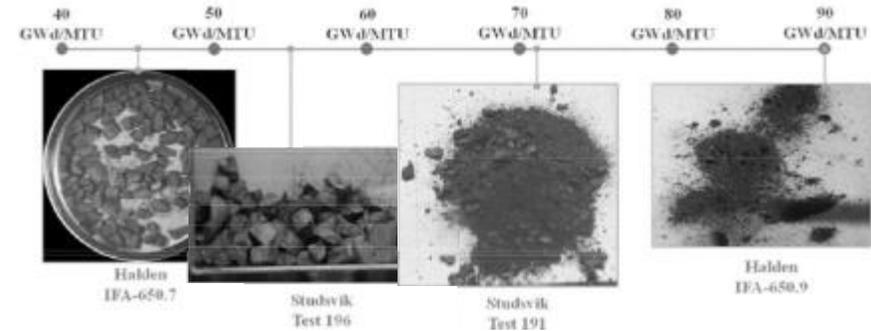
**Licensing, engagement, and collaboration efforts for ATF**

# NRC is ready to license near-term ATF technologies

- Interim Staff Guidance
- Approved ATF-concept topical reports
- Multiple ATF topical reports under review
- ATF license amendment requests for lead test assemblies



# Improving regulatory efficiency, clarity, and certainty



## INCREASED ENRICHMENT RULEMAKING

- Evaluating changes to regulations to facilitate using >5wt% U-235 fuels
- More efficient pathway with increased regulatory certainty and clarity
- Generic resolution that ensures safety
- Increases transparency and stakeholder interaction

## HIGHER BURNUP

- Regulations do not explicitly restrict burnup
- Increasing burnup requires greater consideration of fuel fragmentation, relocation, and dispersal
- Staff analyzing and addressing FFRD in enrichment rulemaking regulatory basis

# Ensuring stakeholder confidence through increased engagement

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Extensively leveraging pre-application meetings to understand technologies to be reviewed



Increasing opportunities for interaction with stakeholders



Cultivating early industry engagement on anticipated submittals

# Participation in ATF programs support continued readiness



## BENEFITS

- Awareness of industry interests
- Latest projects and research strategies
- Update NRC codes and methods
- Continued state of readiness



## FOREIGN AND DOMESTIC

- ATF Testing and Simulation (ATF-TS) with IAEA
- Collaborative Research on Advanced Technology Fuels (CRAFT)
- Inter-agency communications

# Leveraging research for decision-making

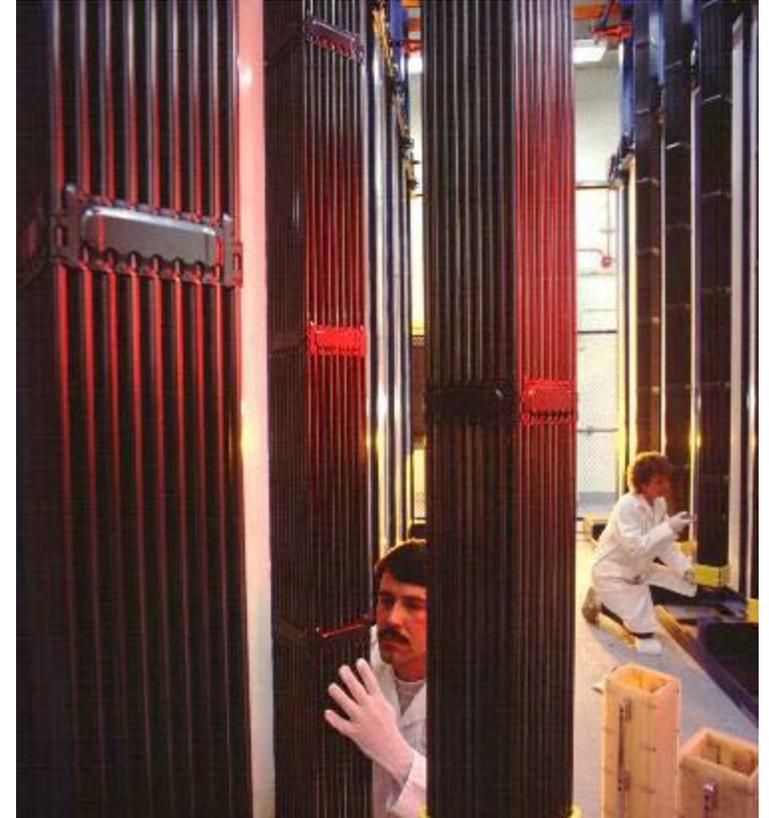
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## BENEFITS

- Advancement of our understanding of ATF technology and modeling capabilities

## WORK PRODUCTS

- Letters and reports: Research Information Letter 2021-13, which discusses FFRD at higher burnup



Damaris Marcano, Chief, Containment, Thermal, Chemical and Fire Protection Branch,  
Office of Nuclear Material Safety and Safeguards

**Licensing and oversight of the enrichment, fabrication, transportation, and  
storage of ATF**

# Effectively implementing strategies for continued readiness

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- Regulatory framework
- Technical information
- Engagement



# Progress in front- and back-end licensing and oversight



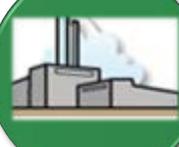
ENRICHMENT

1



FUEL FABRICATION

3



REACTOR

5



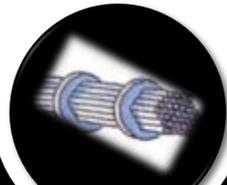
SPENT FUEL STORAGE

7



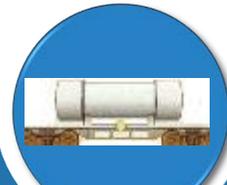
2

UF6 TRANSPORTATION



4

FRESH FUEL TRANSPORTATION



6

IRRADIATED FUEL TRANSPORTATION





# Proactively evaluating our readiness

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- Continue to evaluate our regulatory readiness to identify and address regulatory and technical challenges
- Potential technical areas of focus related to the back end:
  - ✓ Code validation
  - ✓ Short- and long-term data on in-reactor performance
- Continue to perform generic technical assessments and research

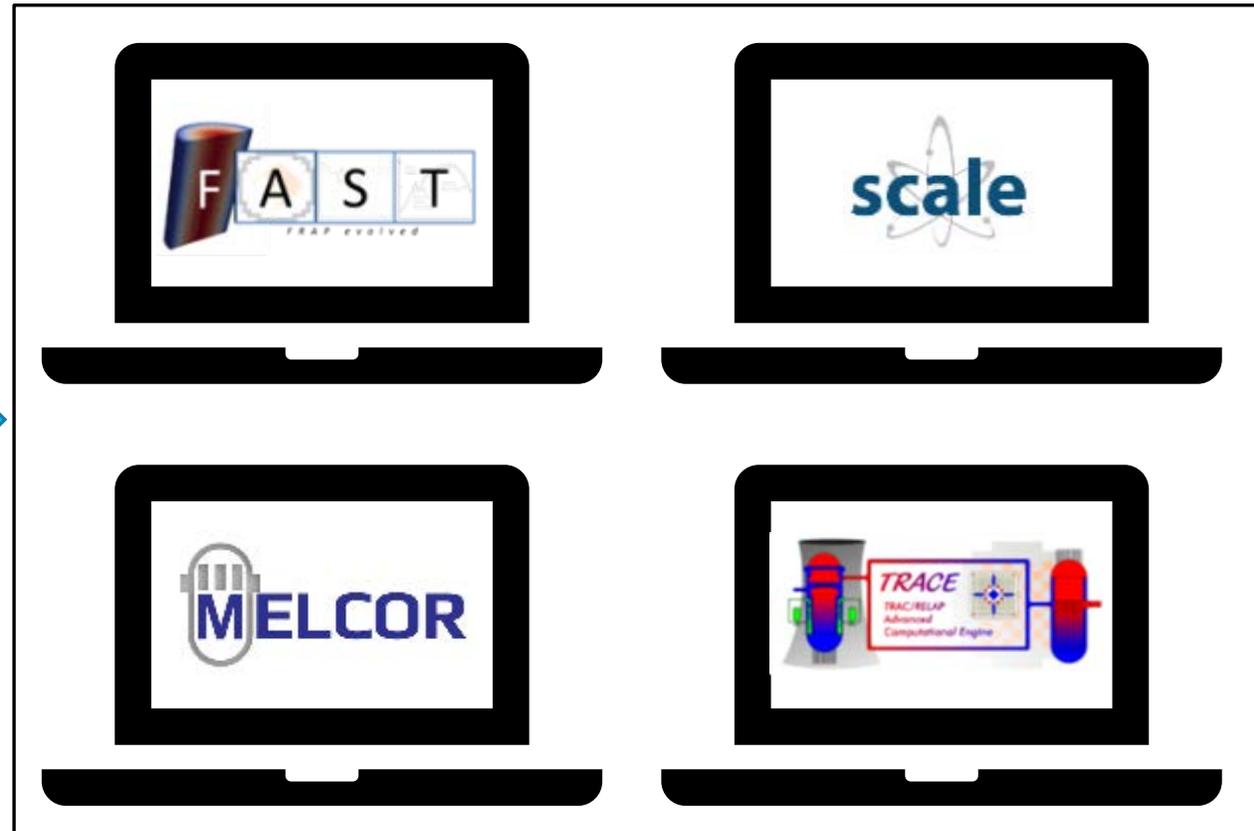
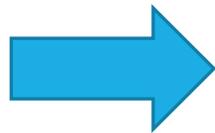


James Corson, Senior Reactor Systems Engineer, Office of Nuclear Regulatory Research

**Confirmatory analysis tools and international research collaboration activities**

# Preparing confirmatory analysis tools to support ATF activities

- Experimental data
- PIRTs
- International collaborative activities



- Licensing actions
- Regulatory Guidance
- Rulemaking

# International research programs inform NRC regulatory efforts

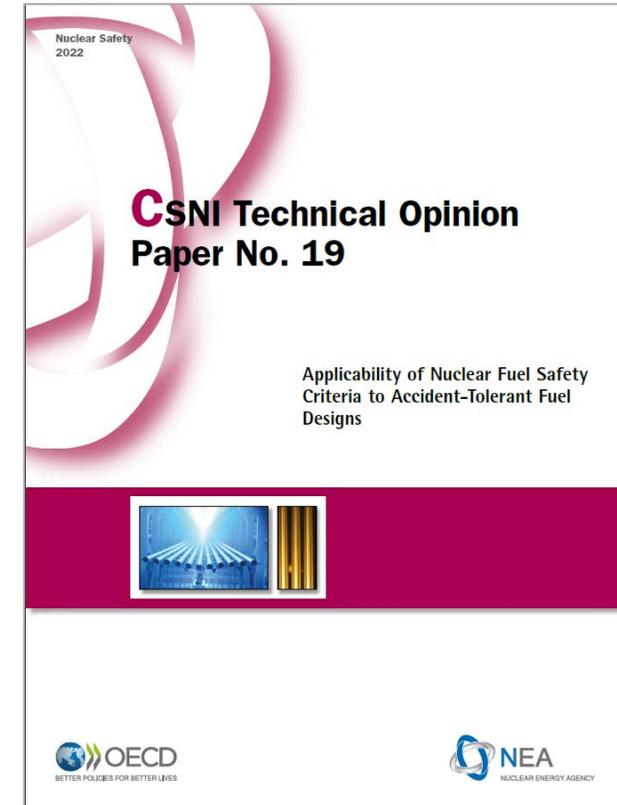
## NEA JOINT PROGRAMS

- Studsvik Cladding Integrity Project (SCIP)
- QUENCH-ATF
- Second Framework for Irradiation Experiments (FIDES-II)



## NEA WORKING GROUP ACTIVITIES

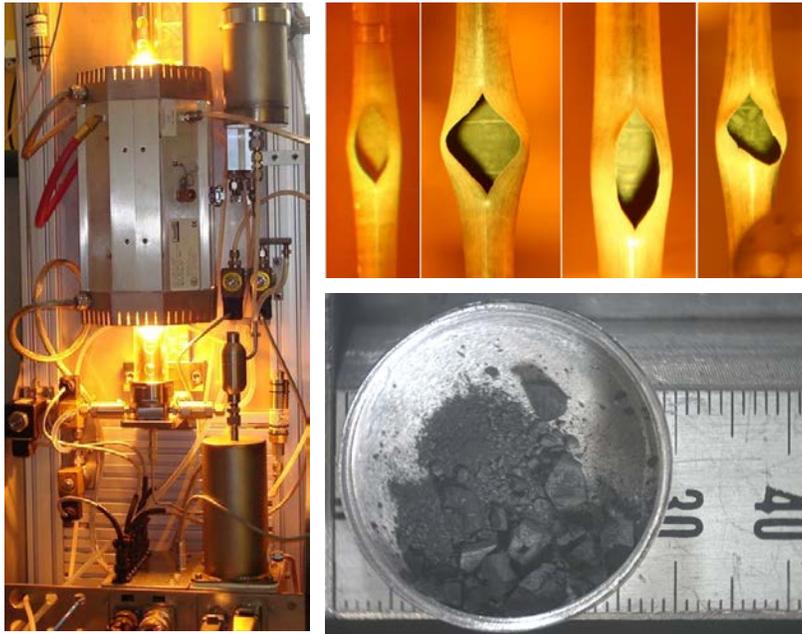
- Topical Opinion Paper on ATF (TOPATF)
- Report on the Safety Implications of Extended Enrichment



# International programs provide data on fuel and cladding behavior during LOCAs

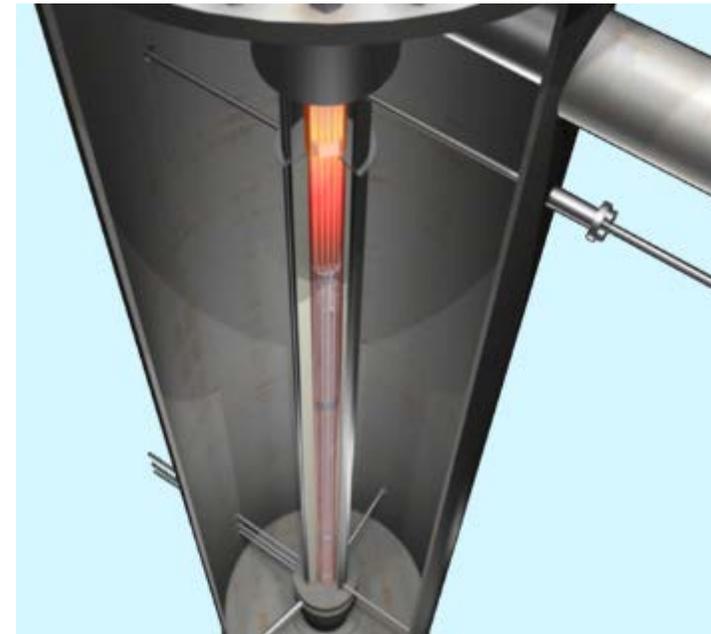
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## SCIP



LOCA test equipment, burst openings, and fuel fragments from SCIP tests

## QUENCH-ATF

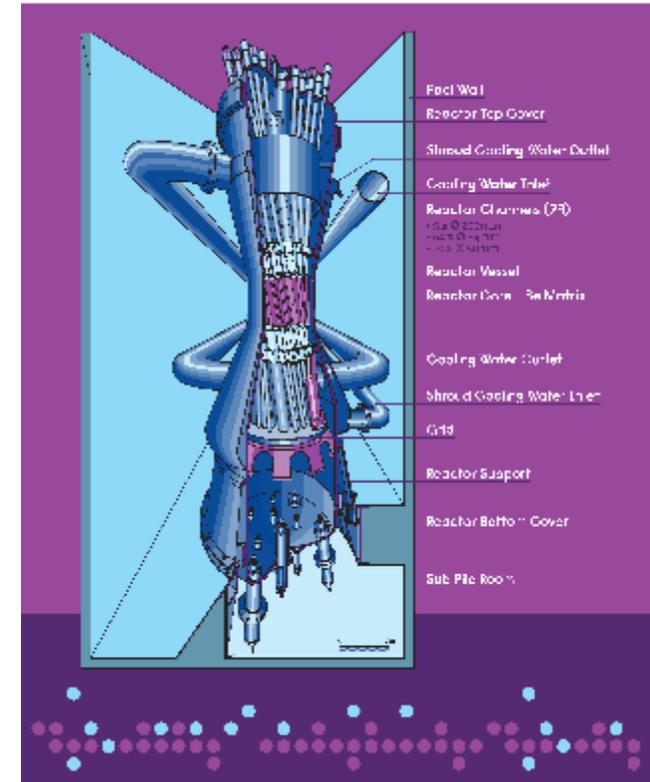


QUENCH facility at KIT

# International collaboration supports guidance updates, code development, and modeling

## FIDES-II INCLUDES THREE JOINT EXPERIMENTAL PROJECTS

- High-burnup Experiments in Reactivity-Initiated Accidents (HERA)
- Power to Melt and Maneuverability (P2M)
- In-pile Creep Studies of ATF Cladding (INCA)



Top Left: TREAT Reactor at INL (Copyright © INL). Bottom Left: LVR-15 Reactor / CVR (Czech Republic). Right: BR2 Reactor Diagram / SCK-CEN (Belgium)



Alice Chung, Reactor Systems Engineer, Office of Nuclear Regulatory Research

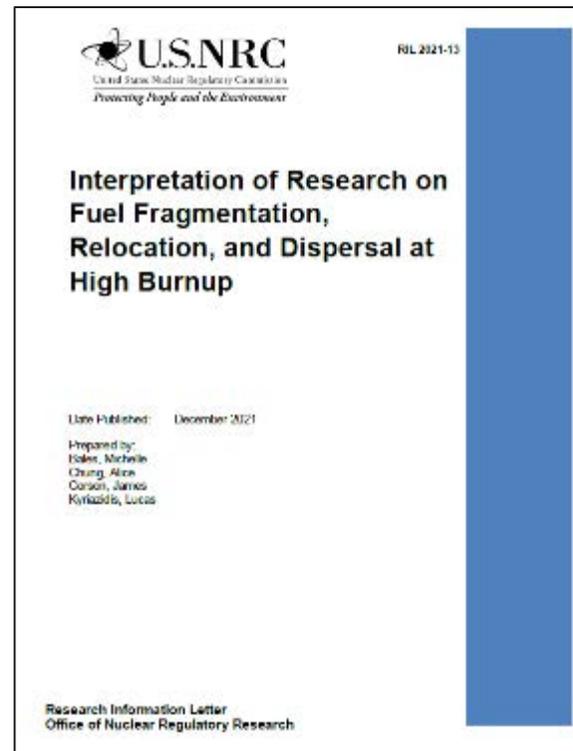
**Modernizing and enhancing staff expertise and tools**

# Research Information Letters support regulatory decisions

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## BY DEFINITION

- Summarize
- Synthesize
- Interpret

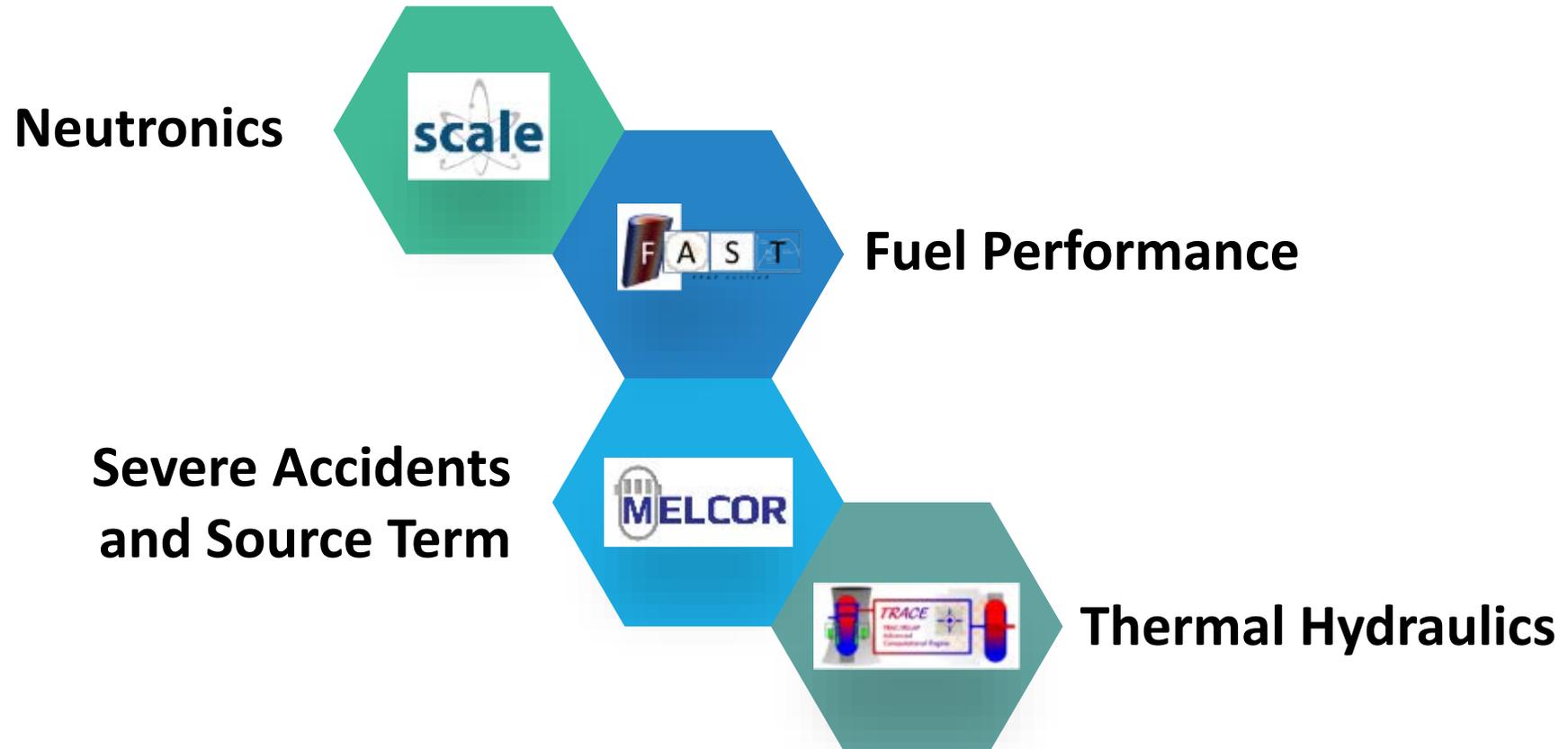


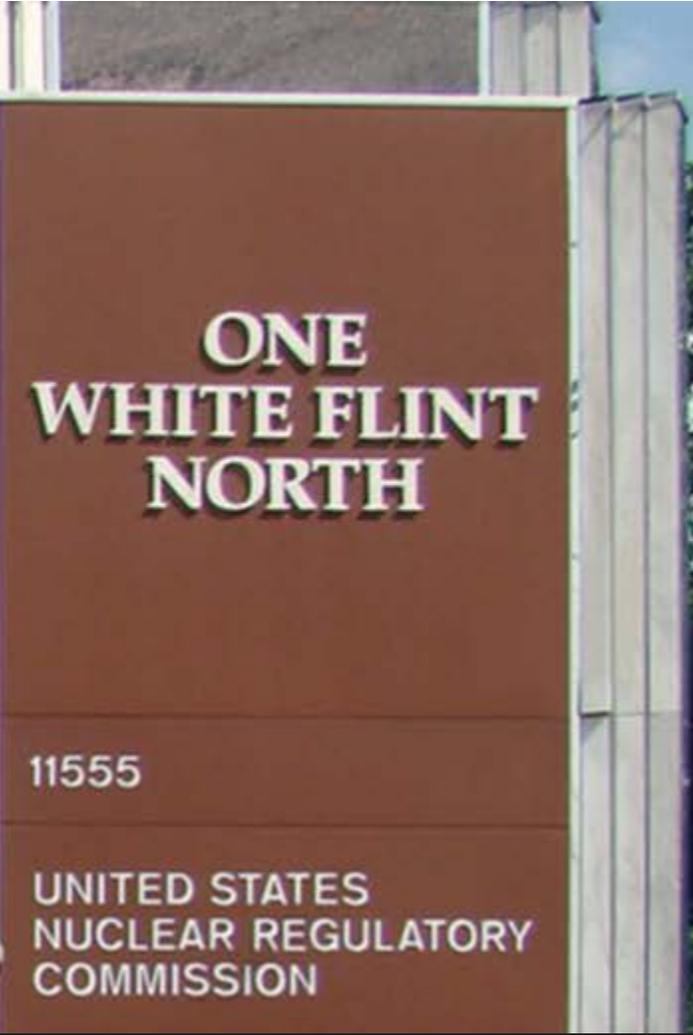
## IN PRACTICE

- Knowledge management
- Technical expertise
- Communication
- Engineering judgment
- Analysis

# Using NRC codes to support ATF decision making

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Dan Dorman, Executive Director for Operations

Closing Remarks