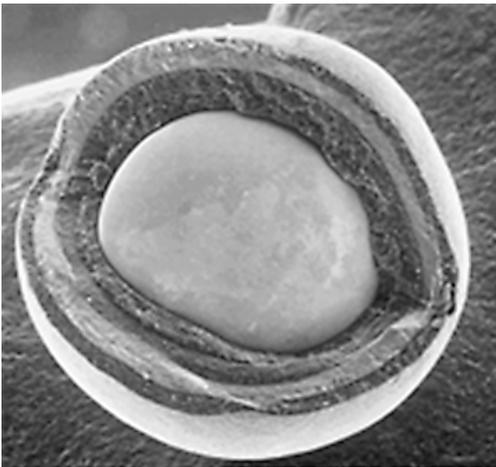


**Nuclear Energy University Program FY19 CINR FOA**  
**Program Supporting: Nuclear Reactor Technologies**  
**HTGR TRISO Fuel Particle Materials (RC-4)**

**THERMOMECHANICAL PROPERTIES OF TRISO**  
**FUEL COATING LAYERS (RC-4.1)**

**EFFECT OF NEUTRON IRRADIATION ON FISSION PRODUCT**  
**TRANSPORT THROUGH TRISO PARTICLE SILICON CARBIDE**  
**COATING LAYER (RC-4.2)**

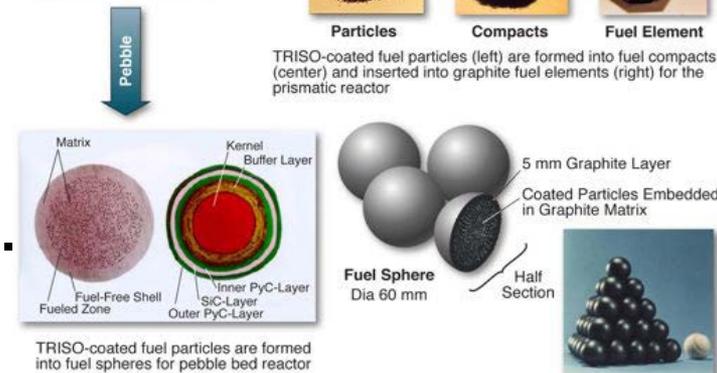
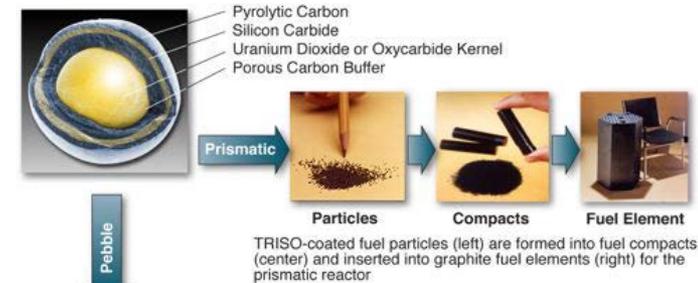
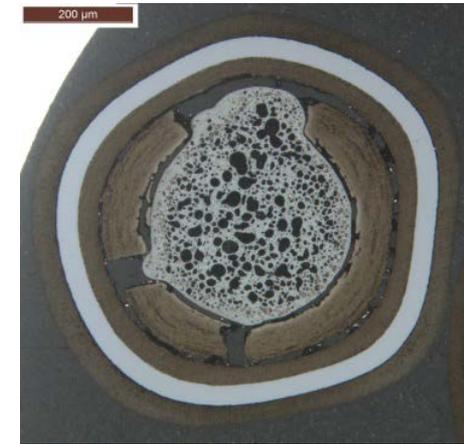


**Dr. Madeline Anne Feltus**  
**DOE Advanced Gas Reactor**  
**TRISO Fuels Program Manager**

## THERMOMECHANICAL PROPERTIES OF TRISO FUEL COATING LAYERS (RC-4.1)

### Motivation for research:

- **Experimental data** is needed to model TRISO fuel performance in simulation codes, e.g., PARFUME.
- Inner PyC coating mechanical failure exposes the inner SiC surface to fission product attack, primarily Pd.
- Focus on **most sensitive properties as a function of neutron irradiation**, e.g., PyC irradiation-induced creep, dimensional changes, elastic modulus, tensile strength.
- Buffer properties and bond strength with IPyC layer (irradiated, un-irradiated) are needed, as well as new measurement techniques.



Eligible to Lead:  
Maximum funding  
Duration:

Universities Only  
\$800,000  
Up to 3 years

# EFFECT OF NEUTRON IRRADIATION ON FISSION PRODUCT TRANSPORT THROUGH TRISO PARTICLE SILICON CARBIDE COATING LAYER (RC-4.2)

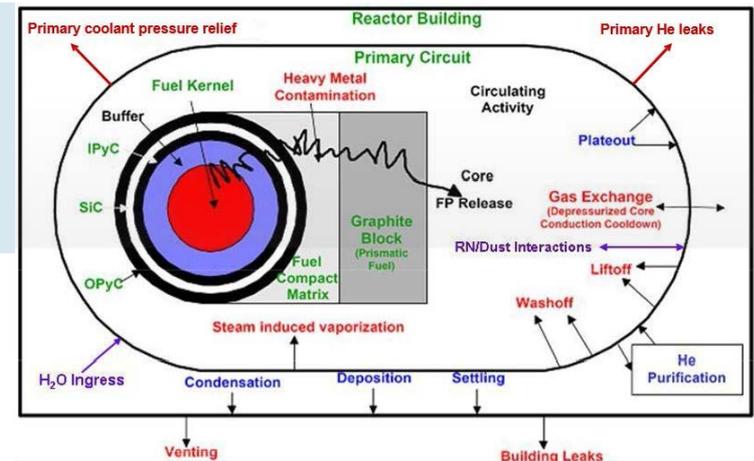
## Motivation for this research:

- Limited work on effects of neutron irradiation-induced polymorphism in SiC
- Intra-granular fission product (FP) precipitation has not been well-explained by any known nucleation mechanism.
- FP nucleation in TRISO SiC occurs in a two step mechanism:
  1. Cubic ( $\beta$ )  $\rightarrow$  hexagonal ( $\alpha$ ) SiC polymorphic transition
  2. Subsequent transition of ( $\alpha$ ) SiC into fission product precipitates
- Potential mitigation of FP precipitate damage effects in TRISO SiC layer, primarily Pd, during high temperature conditions, up to 1600 °C.

Proposals using advanced microscopy (e.g., TEM, HRTEM) and experimental methods on un-irradiated and irradiated TRISO SiC at different dpa are requested.

Eligible to Lead:  
Maximum funding  
Duration:

Universities Only  
\$800,000  
Up to 3 years

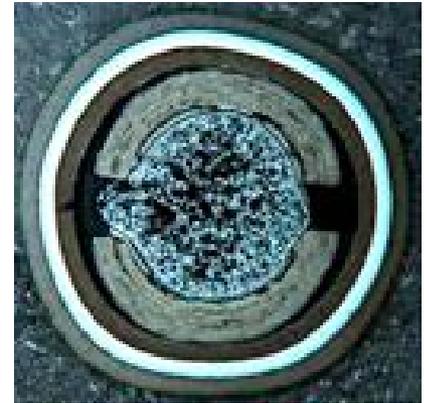


### Proposals **MUST**:

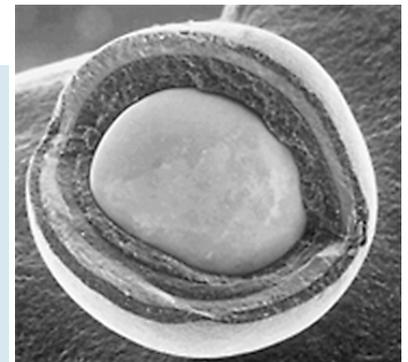
- Focus on obtaining **experimental** data for parameters that have **greater impact** on TRISO particle fuel failure predictions (see: Collin, Skerjanc, INL/EXT-18-44631).
- Use the **most prototypic neutron-irradiated TRISO** buffer, SiC, and/or PyC materials or un-irradiated buffer materials available from the AGR TRISO program.
- Emphasize **carefully designed experiments** that provide new measurements for materials properties and/or characterize newly-observed phenomena for TRISO PIEs.
- Produce **useful** results for TRISO fuel performance code models, input and validation.

Proposals **MUST NOT** focus on developing new computational models (e.g., ab initio or MCNP studies).

Proposals **MAY** develop new correlations based on performing property measurements, microscopy, any new separate effects tests, or irradiation experiments.

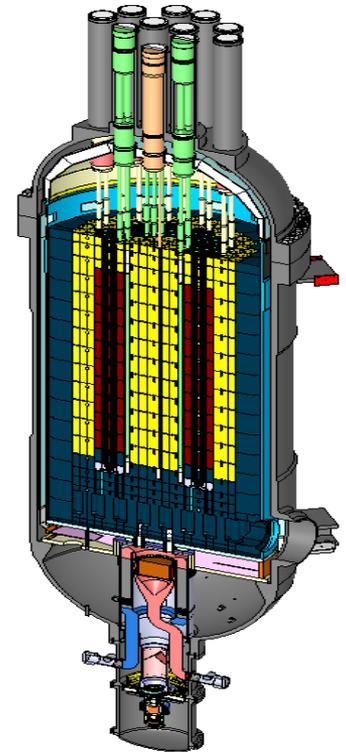


Irradiated  
TRISO



### Proposals should:

- Consider the **effect of neutron irradiation** on TRISO SiC, IPyC, OPyC, buffer and kernel properties and **use irradiated AGR TRISO** specimens as available.
- Focus on **separate effects tests** and **experiments** where results are used to develop prototypic correlations for possible use in existing TRISO fuel performance computer codes.
- Material specimens used should be relevant to AGR TRISO irradiation campaign ranges:
  - Burnup 5% - 20 % fissions per initial metals atoms (FIMA)
  - Fast neutron fluence: 1.0 - 4.5 E25 n/m<sup>2</sup> (E > 0.18 MeV)
  - Irradiation temperature: 900 to 1250°C.
- Use **realistic** ranges for HTGR temperatures, TRISO fuel temperatures, neutron damage rates, based on **vendor** design information.



## HTGR TRISO Fuel Particle Materials (RC-4)

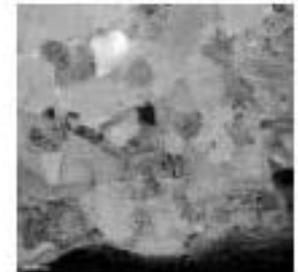
Proposals must **NOT** repeat research or earlier tests performed by NEUP grants and the AGR TRISO Programs\*\*

- Previous SiC specimen layer irradiation damage using proton acceleration (e.g., University of Michigan).
- Previous microscopy (SEM/TEM) studies done by the AGR TRISO program team that have been published.

Proposals *may* repeat some previous research to qualify new measurement techniques, and benchmark neutron irradiation damage if new specimens are made at the university.

\*\* See INL Advanced Reactors Technology, AGR TRISO fuels, NGNP, NEUP websites at:  
<https://art.inl.gov/default.aspx>; <https://neup.inl.gov>

1 nm



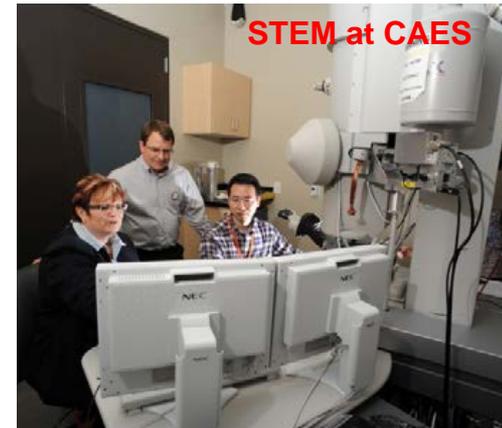
High resolution  
FIB/TEM images  
of precipitate near  
IPyC/SiC  
Interface

## Proposals may:

- Use in-situ university laboratories for surrogate, non-radioactive specimens for TRISO buffer tests.
- Develop new measurement techniques and test rigs that could possibly be used in glove boxes or hot cells for getting data from radioactive specimens.
- Use existing specimens from Advanced Gas Reactor (AGR) TRISO fuel experiments at NSUF locations for hot-cell PIE, SEM, TEM, FIB microscopy, etc.

## Suggestions:

- Coordinate with AGR TRISO Fuel Program team to get appropriate irradiated, un-irradiated specimens.
- Partner with DOE lab staff for advice about hot cell and glove box implementation issues.
- Contact HTGR fuel and reactor vendors about their TRISO fuel, reactor system operations envelope accident scenario conditions.

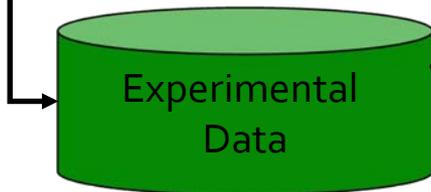


## Quality Assurance Compliance

### Quality Assurance and Data Retention:

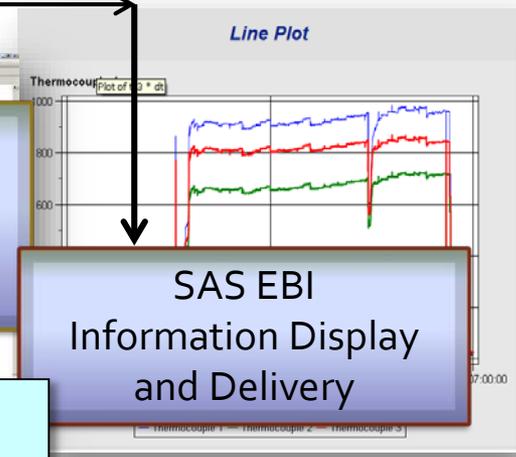
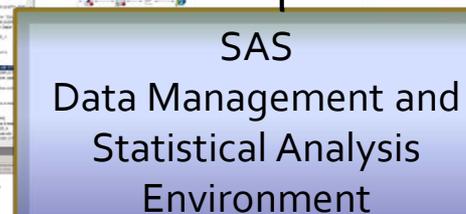
- Data collection, experiments, data validation, and verification may require compliance with NQA-1 2009 and 2009 NRC accepted paragraphs.
- Archiving data and simulation results in the INL Nuclear Data Management and Analysis System (NDMAS) may be required

#### Test Facility Data



firewall

#### NDMAS



## Interested university applicants may contact:

- *Federal POC:*

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**DOE, AGR TRISO Program Manager**

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- *Technical POC:*

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**INL, AGR TRISO Technical Manager**

**[paul.demkowicz@inl.gov](mailto:paul.demkowicz@inl.gov)**

