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

TRISO FUEL BUFFER LAYER BEHAVIOR DURING IRRADIATION (RC-4.1)

ROBUST INDIVIDUAL TRISO-FUELED PEBBLE IDENTIFICATION METHOD FOR EX-CORE EVALUATION (RC-4.2)

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Motivation for research:

- **More insight** is needed to correctly model TRISO fuel performance in simulation codes, e.g., PARFUME.
- Inner PyC (IPyC) coating mechanical failure exposes the inner SiC surface to fission product attack, primarily Pd.
- Buffer properties and bond strength with IPyC layer data (irradiated, un-irradiated) may not be known for use in models for performance simulation codes.
- Need to explicitly **model buffer/IPyC layer evolution as a function of neutron irradiation**, i.e., how the buffer interacts with IPyC layer during irradiation as buffer densifies and shrinks.

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**eligible to Lead: Universities Only**

**Maximum funding:** $800,000

**Duration:** Up to 3 years
Proposals for RC-4.1 should:

- Focus on **modelling** TRISO particle buffer/IPyC evolution and failure mechanisms.
- Consider what parameters have the **greatest impact** on TRISO particle fuel buffer/IPyC evolution and failure mechanisms.


**RC-4.1 proposals should develop new models that capture the kernel, buffer, and IPyC phenomena observed in AGR irradiation tests and PIEs.**
Proposals for RC-4.1 should:

- Capture the **effects of neutron irradiation** on TRISO IPyC layer, buffer and kernel and use parametric studies over a range of material properties where existing properties do not currently exist.

- Use **realistic** ranges for HTGR temperatures, TRISO fuel temperatures, neutron damage rates, based on vendor design information.

Examples of IPyC cracks causing SiC degradation and fracture because buffer was not detached where buffer fractured.
The primary thrust is on new models; however, proposals for RC-4.1 may:

- Consider performing separate effects experiments where results could be used to develop behavioral or material property correlations that may be applied in TRISO fuel performance models.

- Use university research reactor tests with surrogates or experiment with non-irradiated TRISO fuel specimens.

- Develop new property measurement techniques that could be used potentially in glove boxes or hot cells for obtaining data from radioactive specimens.

- Produce new microscopy results using actual AGR TRISO program irradiated specimens to develop specific data that describes buffer/IPyC interaction phenomena for correlations and model development.

- Use actual Advanced Gas Reactor (AGR) TRISO Fuel irradiated test specimens at NSUF locations for hot-cell PIE, SEM, TEM, FIB microscopy, etc.

Suggestions:

- Coordinate and partner with AGR TRISO Fuel Program lab staff to get access to appropriate specimens, advice about implementing new measurement methods in hot cells.

- Contact TRISO fuel and reactor vendors about their fuel and system normal operational and accident scenario conditions.
ROBUST INDIVIDUAL TRISO-FUELED PEBBLE IDENTIFICATION METHOD FOR EX-CORE EVALUATION (RC-4.2)

Motivation for this research:

- Pebble bed fuel moves stochastically through core
  - Gas-cooled: downward (e.g., X-energy)
  - Salt-cooled: upwards (e.g., Kairos)
  - Ex-core monitoring system for burnup
  - Core reinsertion or spent fuel storage

Tagging, tracking individual pebbles would be useful for:

- Determining individual residence time
- Avoiding excessive burnup
- Reducing uncertainty in pebble “flow line” computational models
- Addressing material control and accountability, and proliferation resistance issues

Eligible to Lead: Universities Only
Maximum funding: $800,000
Duration: Up to 3 years
Proposals for RC-4.2 should:

- **FOCUS** on obtaining a robust, reliable tagging method that can handle:
  - Potential abrasion, corrosion, or degradation of pebble surface
  - High temperature, high neutron flux environment
  - Track and catalogue large number of pebbles (hundred of thousands)
  - Ex-core pebble burnup measurement systems (neutron, gamma)
  - Relatively rapid “reading” time ≤ burnup measurement system time to meet pebble throughput requirements.
  - Track each individual pebble’s being reinserted into the core or sent to spent fuel storage

- **MAY** develop new computational algorithms or models that use this pebble tagging and tracking method and its data for reducing the uncertainty of pebble flow simulation models.

- **NOT** develop new burnup measurement/monitoring systems
Proposals must **NOT** repeat research or earlier tests performed by NEUP grants and the AGR TRISO Program**

Proposals that develop new measurement methods **may** repeat some previous research to qualify and benchmark these measurement techniques.

RC-4.1 proposals **should** use AGR TRISO program microscopy (SEM/TEM) results to benchmark any computational models or correlations developed for describing buffer/IPyC behavior.

RC-4.2 proposals **should NOT** develop ex-core burnup monitoring systems, but **focus** on pebble tagging and tracking methods.

** See INL Advanced Reactors Technology, AGR TRISO fuels, NGNP, NEUP websites at:

https://art.inl.gov/default.aspx

https://neup.inl.gov
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.
Interested university applicants may contact:

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