NSUF Fuel Irradiation Test – Project Update

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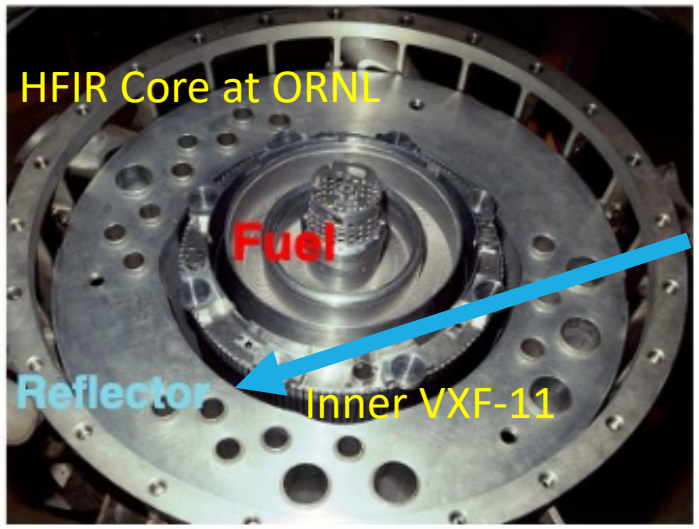
Kairos Power's mission is to enable the world's transition to clean energy, with the ultimate goal of dramatically improving people's quality of life while protecting the environment.

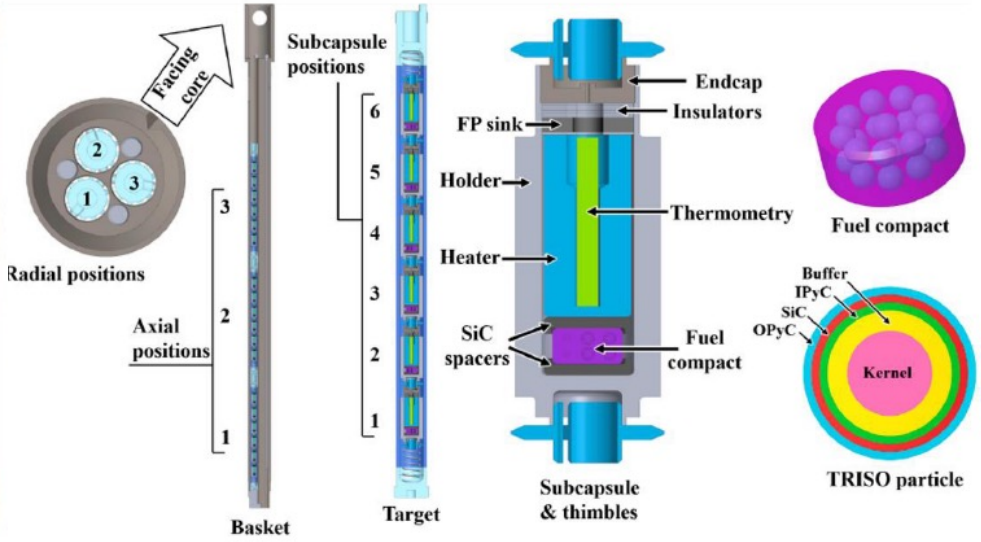
In order to achieve this mission, we must prioritize our efforts to focus on a clean energy technology that is *affordable* and *safe*.

Kairos Power NSUF Project
HFIR Irradiation of TRISO Fuel at High Powers

- Investigate fuel performance of TRISO fuel particles at powers considerably greater than the DOE AGR irradiation tests.
- Heat transfer properties of molten salt allow for high power density >20MW/m^3
- Project award ~$3M over 5 years
- Timeline
  - Test Design/Fabrication 10/19 – 6/21
  - Irradiation 6/21 – 1/22
  - PIE 6/22 → 2025

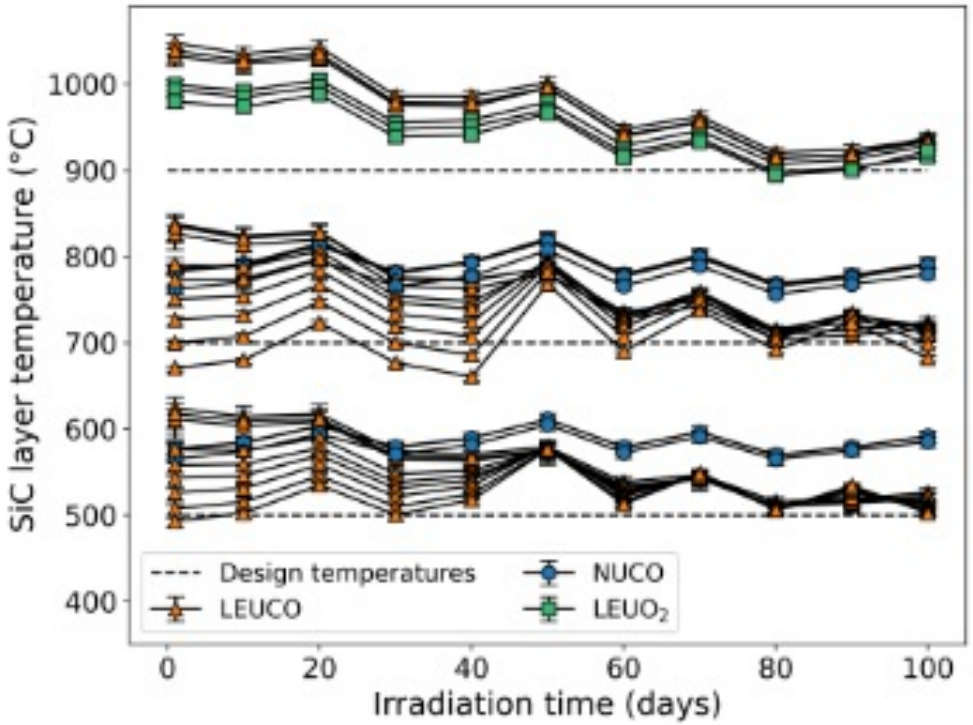


ORNL MiniFuel Test



Irradiation Test in HFIR at ORNL

- Miniature fuel compacts
  - 20 AGR-2 TRISO particles in a 4.6mm dia. x 2.3mm ht. carbon matrix compact
  - Kernel types – Natural & Enriched UCO, Enriched UO_2
- Capsules
  - 30 sub-capsules in 5 irradiation targets
- Irradiation
  - Power 70-1000 mW/particle
  - Burnup up to 12.4 %FIMA in ~104 days
  - Time averaged SiC layer temperatures – 550C, 750C, 950C



Irradiation Targets with Sub-Capsules

PIE – Status Update

- All sub-capsules were gas punctured
- Sub-capsule disassembly and SiC thermometry is ongoing
- Selective gamma scanning of sub-capsules and components
- Six representative minifuel compacts will undergo destructive examination

Capsule ID	Kernel Type	Gas Puncture	Disassembly	SiC Thermometry	Gamma Scan
KP121	LEUCO	X	X	X	
KP122	UO2	X	X	X	
KP123	LEUCO	X	X	X	X
KP124	UO2	X	X	X	X
KP125	LEUCO	X	X	X	
KP126	UO2	X	X	X	
KP221	LEUCO	X			
KP222	NUCO	X	X	X	
KP223	LEUCO	X	X	X	X
KP224	NUCO	X	X	X	X
KP225	LEUCO	X	X		
KP226	NUCO	X	X	X	
KP231	LEUCO	X			
KP232	LEUCO	X			
KP233	LEUCO	X			
KP234	LEUCO	X			
KP235	LEUCO	X			
KP236	LEUCO	X			
KP321	LEUCO	X			
KP322	NUCO	X			
KP323	LEUCO	X	X	X	X
KP324	NUCO	X	X	X	X
KP325	LEUCO	X			
KP326	NUCO	X			
KP331	LEUCO	X			
KP332	LEUCO	X			
KP333	LEUCO	X			
KP334	LEUCO	X			
KP335	LEUCO	X			
KP336	LEUCO	X			

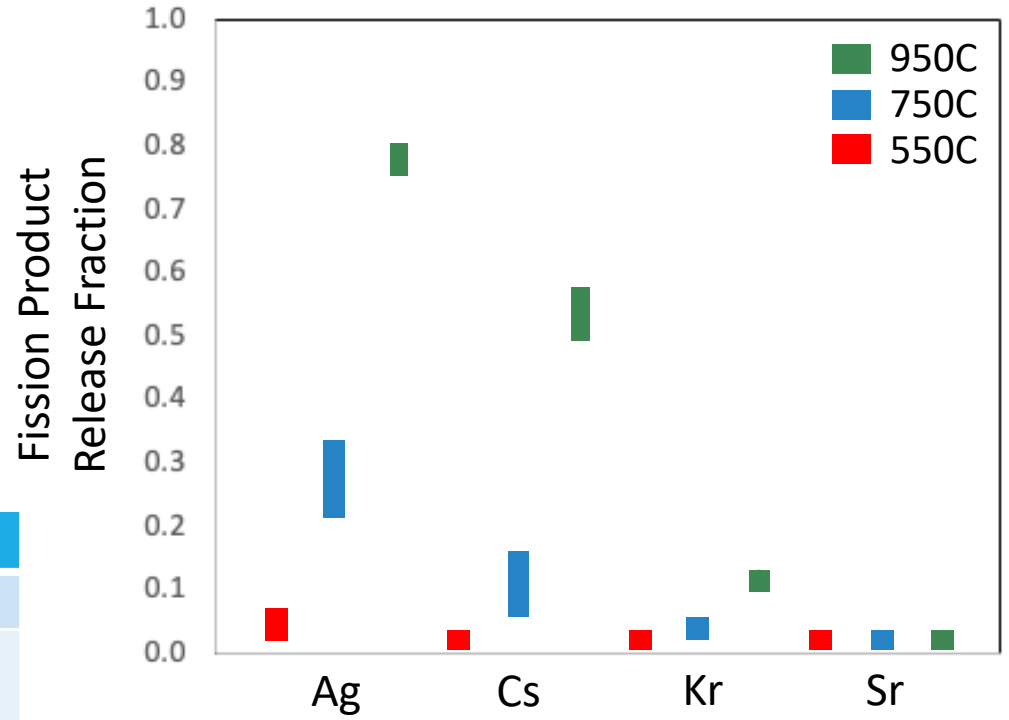
KP-BISON – Fuel Performance

- Fuel performance predictions used to guide PIE and for comparison with results
- All irradiation test capsules were simulated
- High failure probability for IPyC layer associated with low irradiation temperatures
- Fission product release was calculated assuming failure of all coating layers

Failure Probability – Coating Layers

TRISO Kernel Type	UCO	NUCO	UO_2
IPyC Failure Probability	4.3e-4 - 0.25	0.16 - 0.20	0.025 - 0.031
SiC Failure Probability due IPyC Failure	1.3e-8 - 1.1e-3	6.8e-4 - 1.1e-3	3.2e-5 - 4.3e-5

Fission Product Release Fraction for Failed TRISO fuel Particles with SiC Layer Temperature



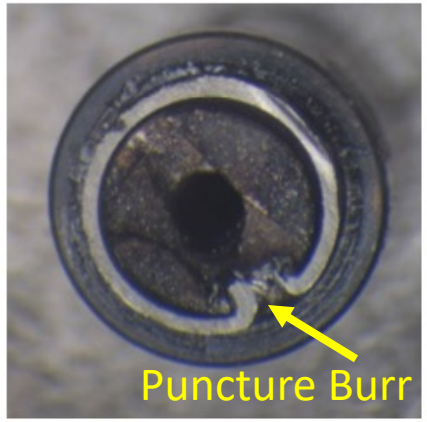
Gas Puncture - FGR

- All irradiated sub-capsules were gas punctured for fission gas release
- No failures detected in UCO TRISO particle sub-capsules
- Likely failure(s) in a sub-capsule with UO_2 TRISO particles
  - KP-BISON predicts 11-13% FGR with failure of all coating layers
  - Measured Kr-85 activity was on the order of one TRISO particle failure
- Results indicate no LEUCO TRISO particle failures of all coating layers for the very high particle power irradiation test

Parameter	NSUF	AGR-2	AGR-5/6	AGR-7
Peak Particle Power (mW)	1000	155	247	238
Ave. Particle Power (mW)	386	73	107	148
Peak Burnup (%FIMA)	12.4	13.2	15.3	15.0

Sub-capsule Disassembly

Gas Punctured and Sectioned

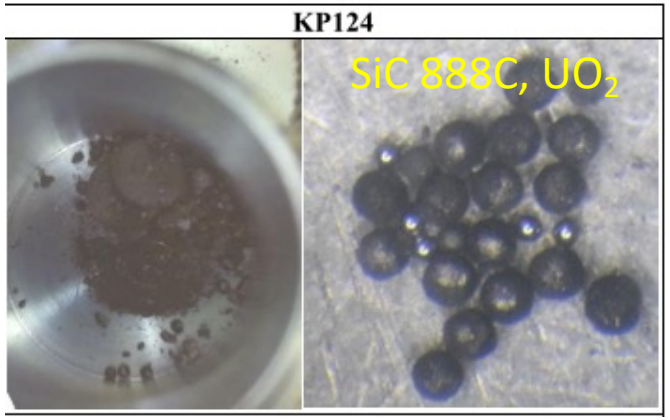


Sub-capsule Sectioning

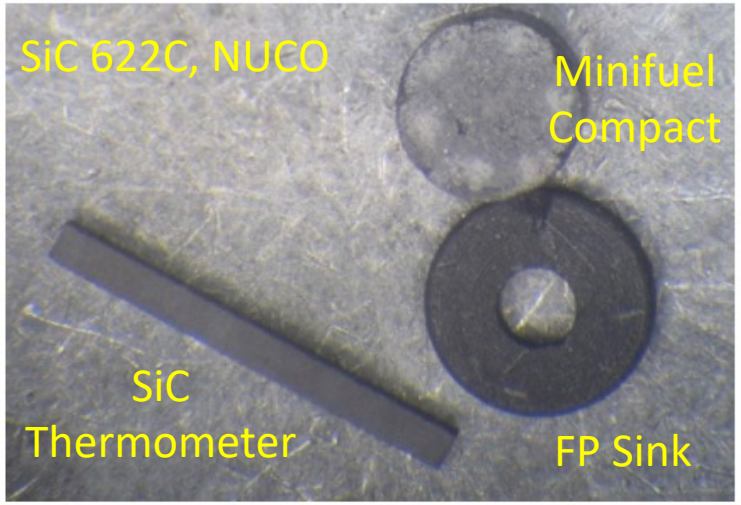
Gamma scans complete on 6 sub-capsules

- No indication of fuel failure
- No measurement of Cs release in the sub-capsule (in the FP sink)

Mini-fuel Post-Irradiation



500-micron ball bearings shown for size comparison, not part of test



Future PIE to Complete Irradiation Study

- NSUF funds selective destructive examination (at least 6 minifuel compacts), including:
  - Deconsolidation Leach Burn Leach (DLBL)
  - IMGA [Validation of intact particle layers, e.g., Cs retention / loss]
  - XCT [3D imaging of individual TRISO particle layers and kernel]
  - Ceramography & Microscopy [2D cross section images to further evaluate the kernel and the TRISO particle layers]
- One year no cost extension to project to complete the full work scope
- ARDP CRADA funds comprehensive destructive examination to complete sub-capsules, as desired
- Additional PIE will provide further mechanistic understanding of high particle power irradiation performance to inform KP-BISON