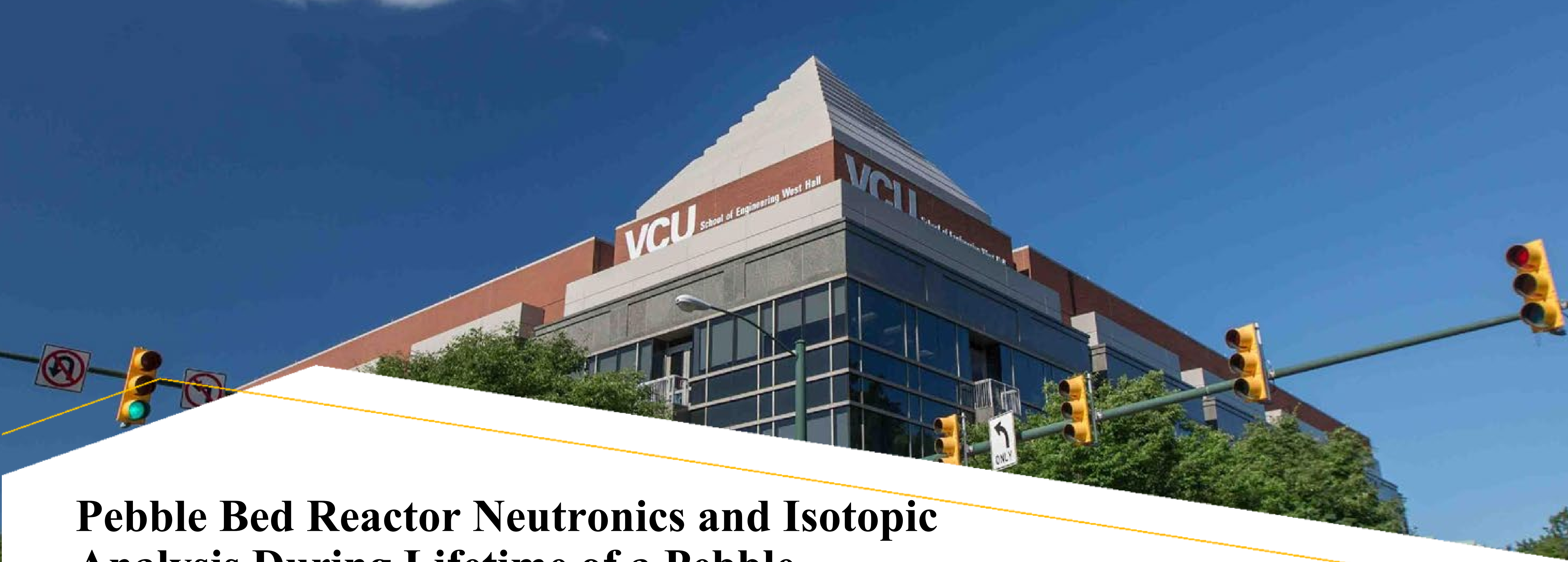


Pebble Bed Reactor Neutronics and Isotopic Analysis During Lifetime of a Pebble

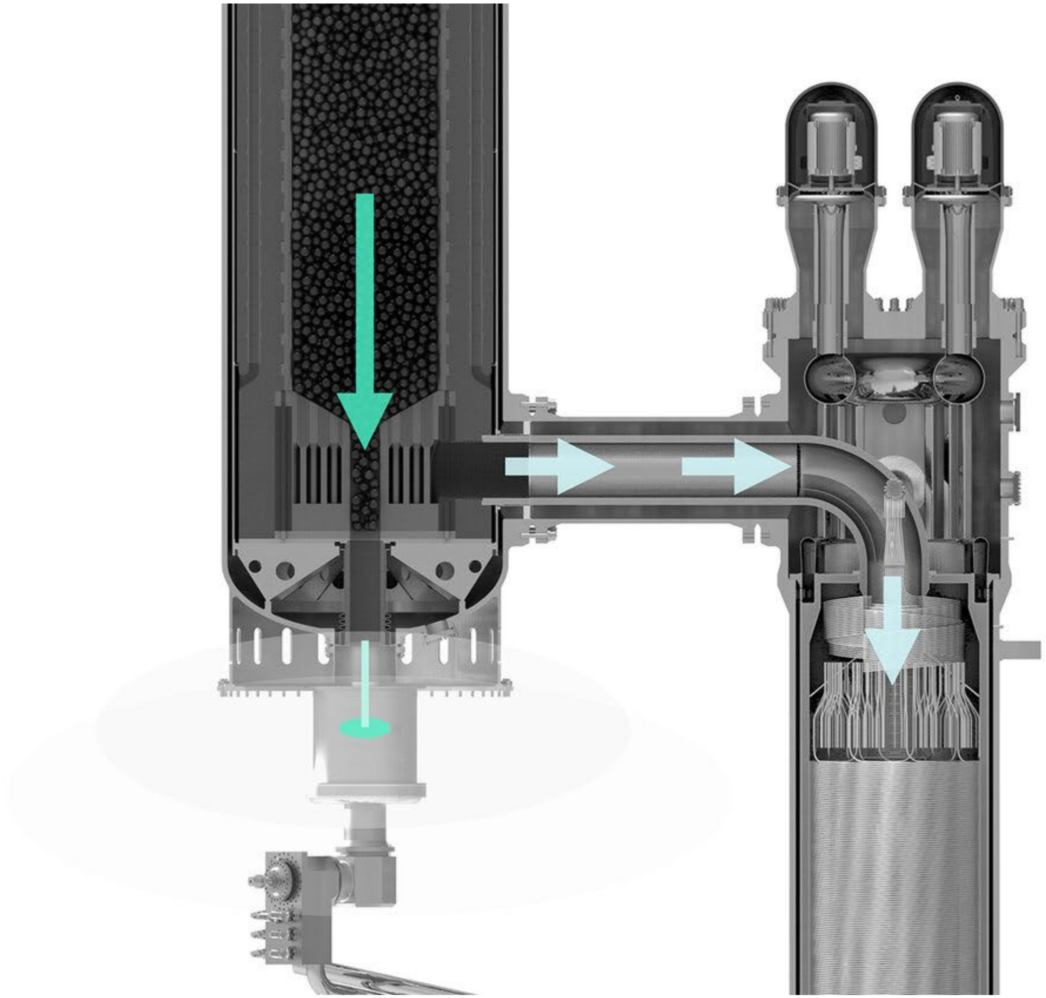
Zachary Crouch, Braden Goddard, Zeyun Wu, and Ben Impson

Virginia Commonwealth University, Department of Mechanical and Nuclear Engineering

VCU College of Engineering

Pebble Life Cycle

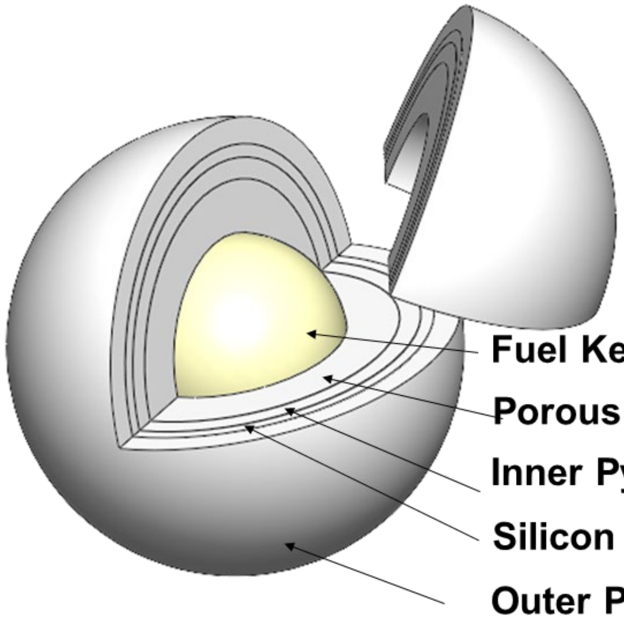
- Pebbles are intended to cycle through the core
- There is a possibility of reusing “spent” pebbles
- Determining viability is difficult without destructive assay



Radiation Spectrum Analysis

- Radiation spectrum analysis, including gamma and neutron radiation can be used to determine pebble isotopics
- Without access to actual "spent" pebbles, analysis can be done with MCNP6 to determine mass at different points in the life cycle

TRISO Fuel Particle Configurations

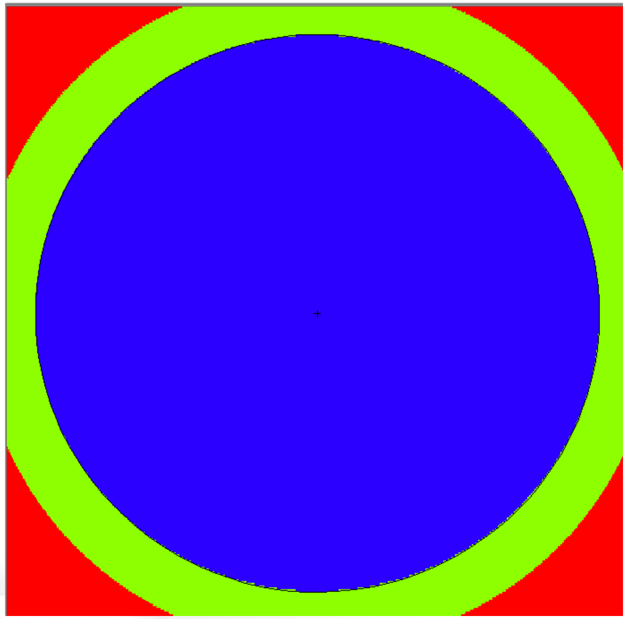


Material	Density (g/cc)	Radius (cm)
UCO Fuel	10.90	2.13E-02
Buffer	1.00	3.13E-02
PyC1	1.90	3.53E-02
SiC	3.20	3.93E-02
PyC2	1.90	4.28E-02

Variable Material Configurations

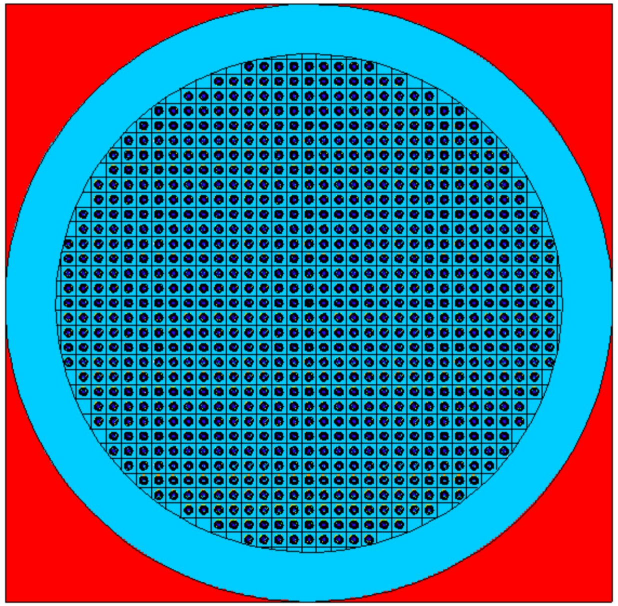
Homogeneous

- Center of the pebble is an undifferentiated mixture of TRISO components



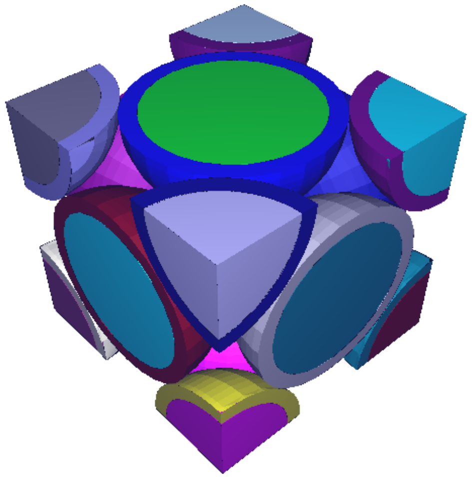
Heterogeneous

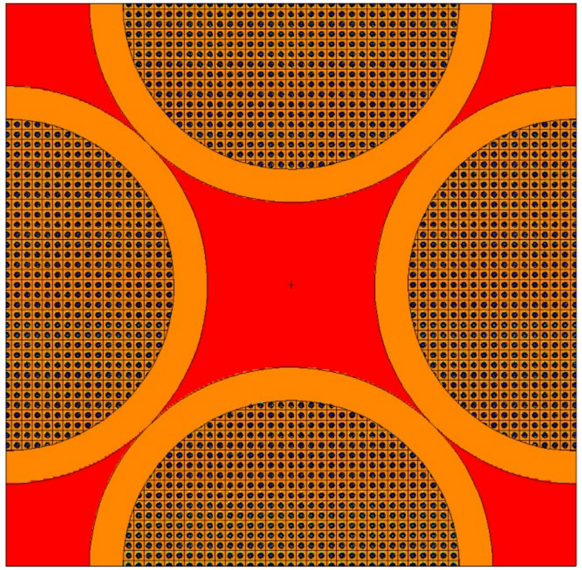
- Center of the pebble is discretized into individual TRISOs (approximately 19,000)



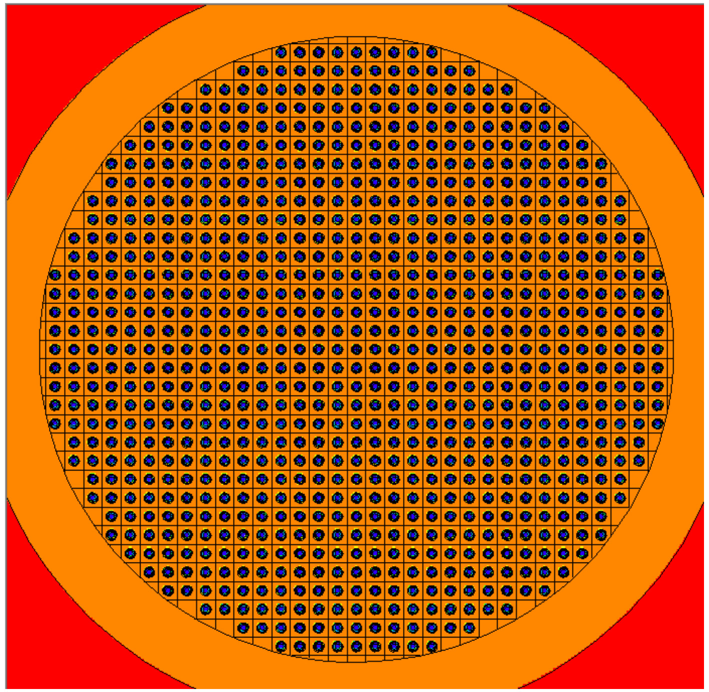
Variable Geometry Configurations

Face Centered Cubic (FCC)





Single Pebble



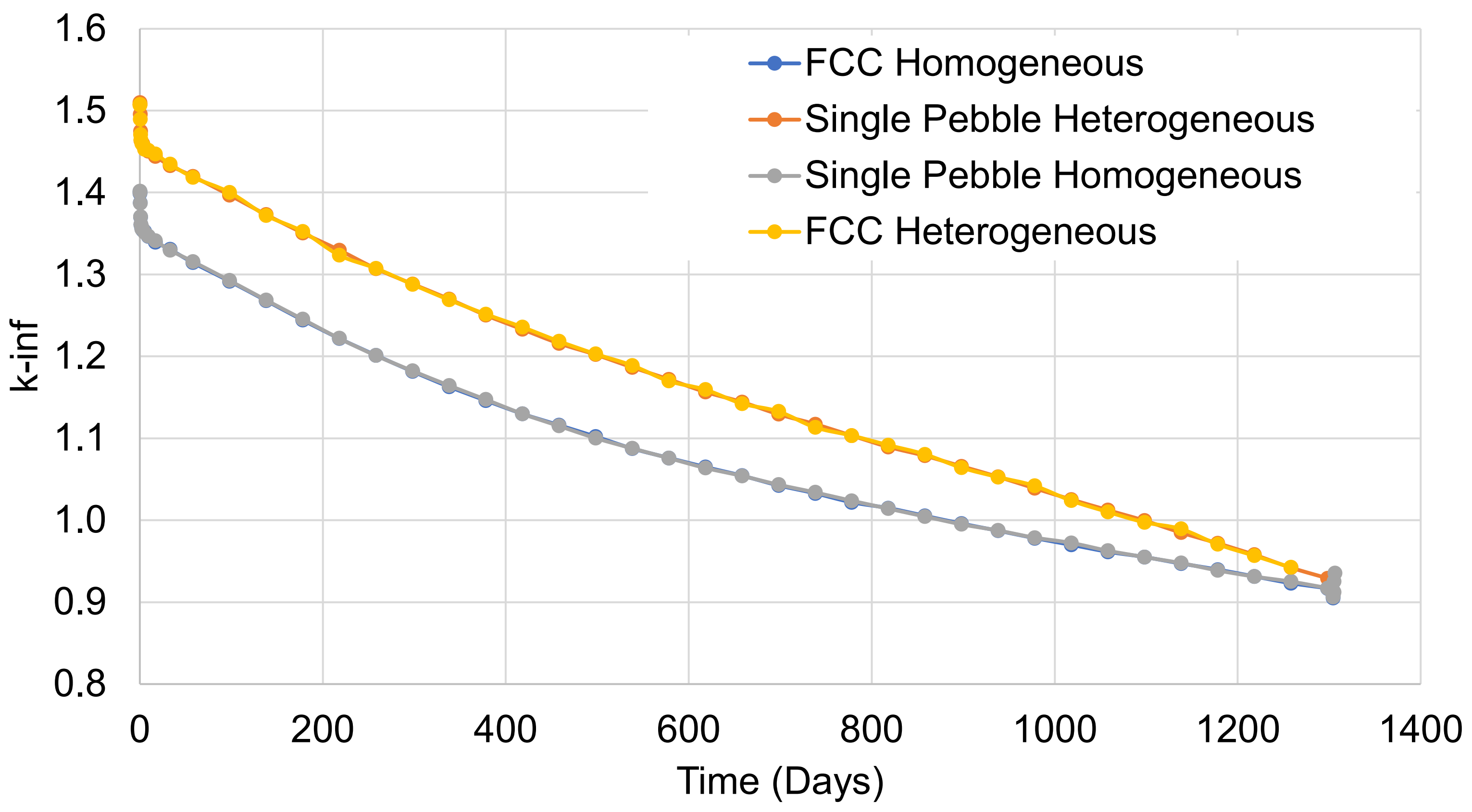
Fresh k-inf (no burnup, 15.5% enriched)

Model	k-inf	Standard Deviation
Single Pebble Homogeneous	1.40254	0.00071
FCC Homogeneous	1.40155	0.00082
Single Pebble Heterogeneous	1.50991	0.00075
FCC Heterogeneous	1.50800	0.00065

Burnup Results

k-inf over time

- Same 15.5% enrichment
- 1304 days at full power
- Burnup accurate to Xe-100 with max 160,000 MWd/MTU



Isotope Comparison, FCC Pebble End of Life

Isotopes in grams	U-235	U-238	Pu-239	Pu-240	Am-241	Cm-244
Homogeneous	2.80×10^{-1}	5.43×10^{0}	1.12×10^{-1}	4.63×10^{-2}	1.42×10^{-3}	2.83×10^{-3}
Heterogeneous	1.86×10^{-1}	5.62×10^{0}	5.31×10^{-2}	3.51×10^{-2}	5.44×10^{-4}	2.84×10^{-3}

Conclusions

- Geometry has no statistical impact on k-inf or burnup
- Material configurations have considerable impact, discrete particles are more accurate, seen in increased actinides in homogeneous models

Acknowledgements

- This work is performed with the support of U.S. Department of Energy's Nuclear Energy University Program (NEUP) with the Award No. DE-NE0009304