RADIANT

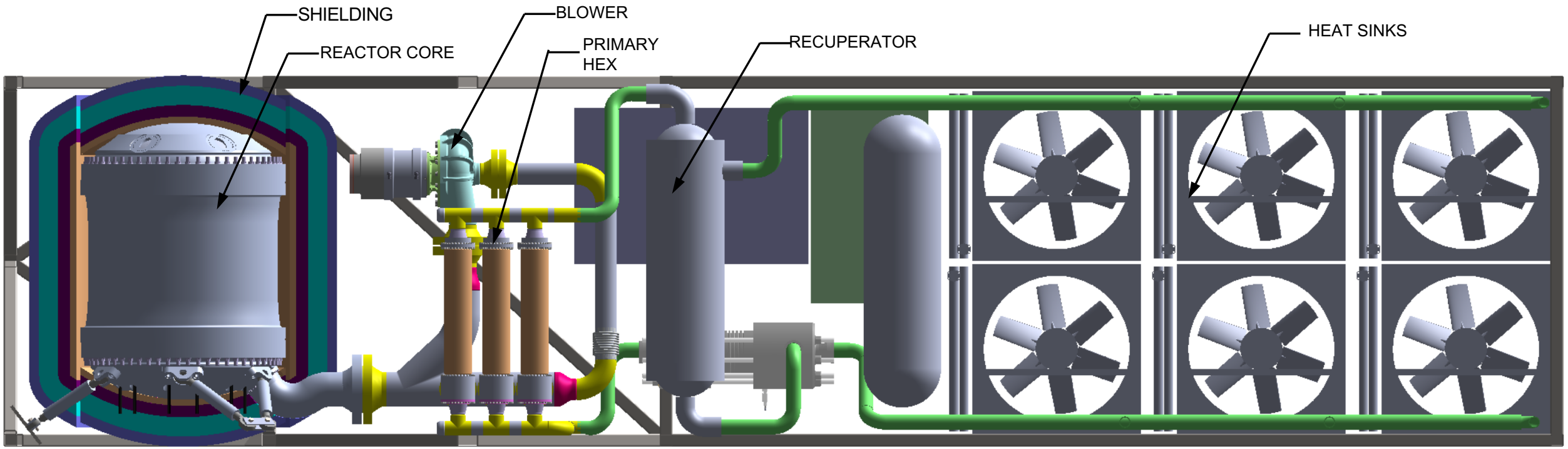
Kaleidos

Overview of a Portable, High Temperature Gas-Cooled Microreactor Demonstration Unit Design

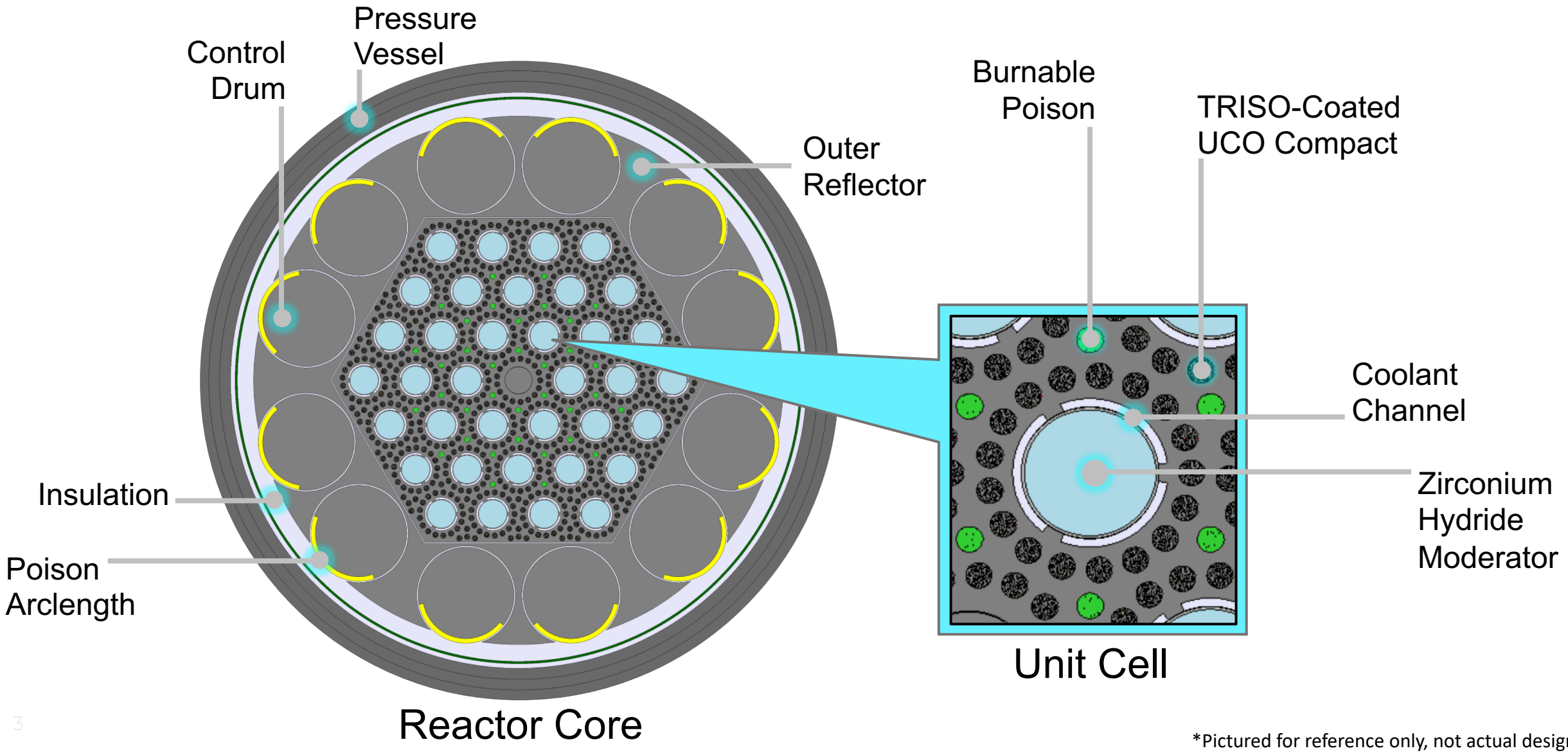
June 20th, 2023

Kaleidos Overview

- Power output of 3.5 MWt, 1 MWe
- Factory refueled, no waste left on-site
- 5-year energy source equivalent to 5,500 tons of diesel fuel per core
- TRISO-coated UCO fuel
- Helium primary loop coolant
- Passive cooling air jacket

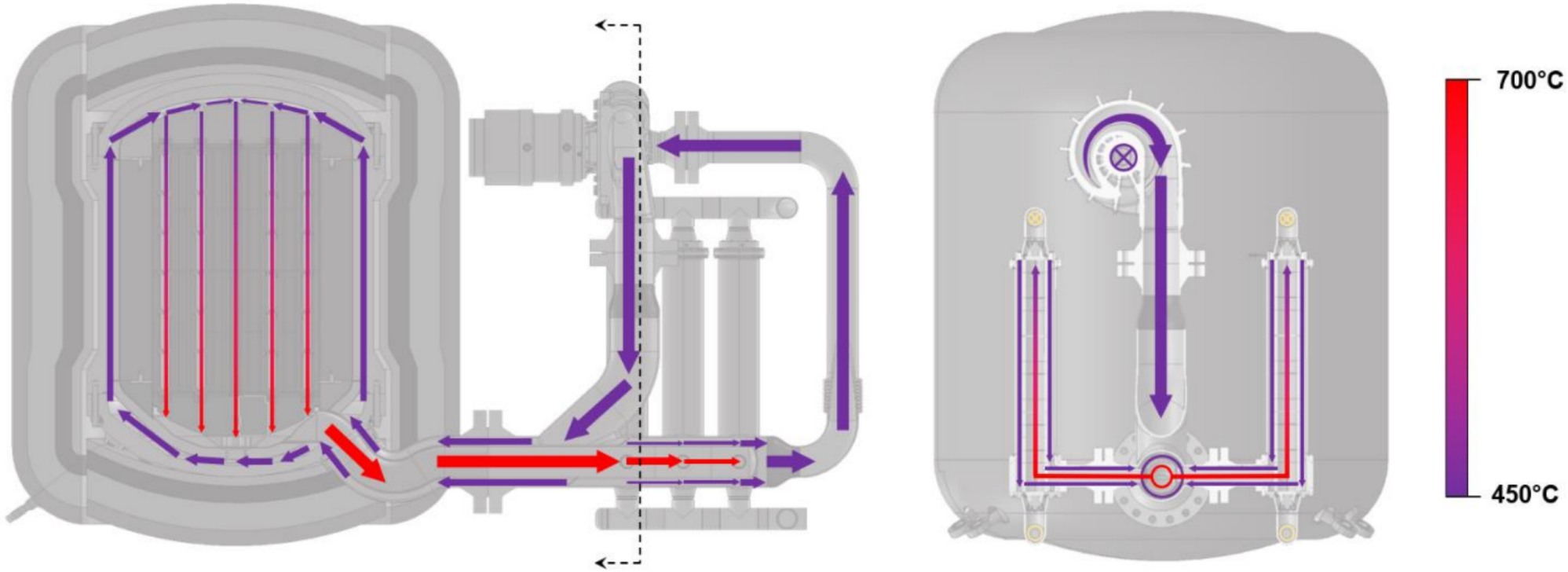


Core Design



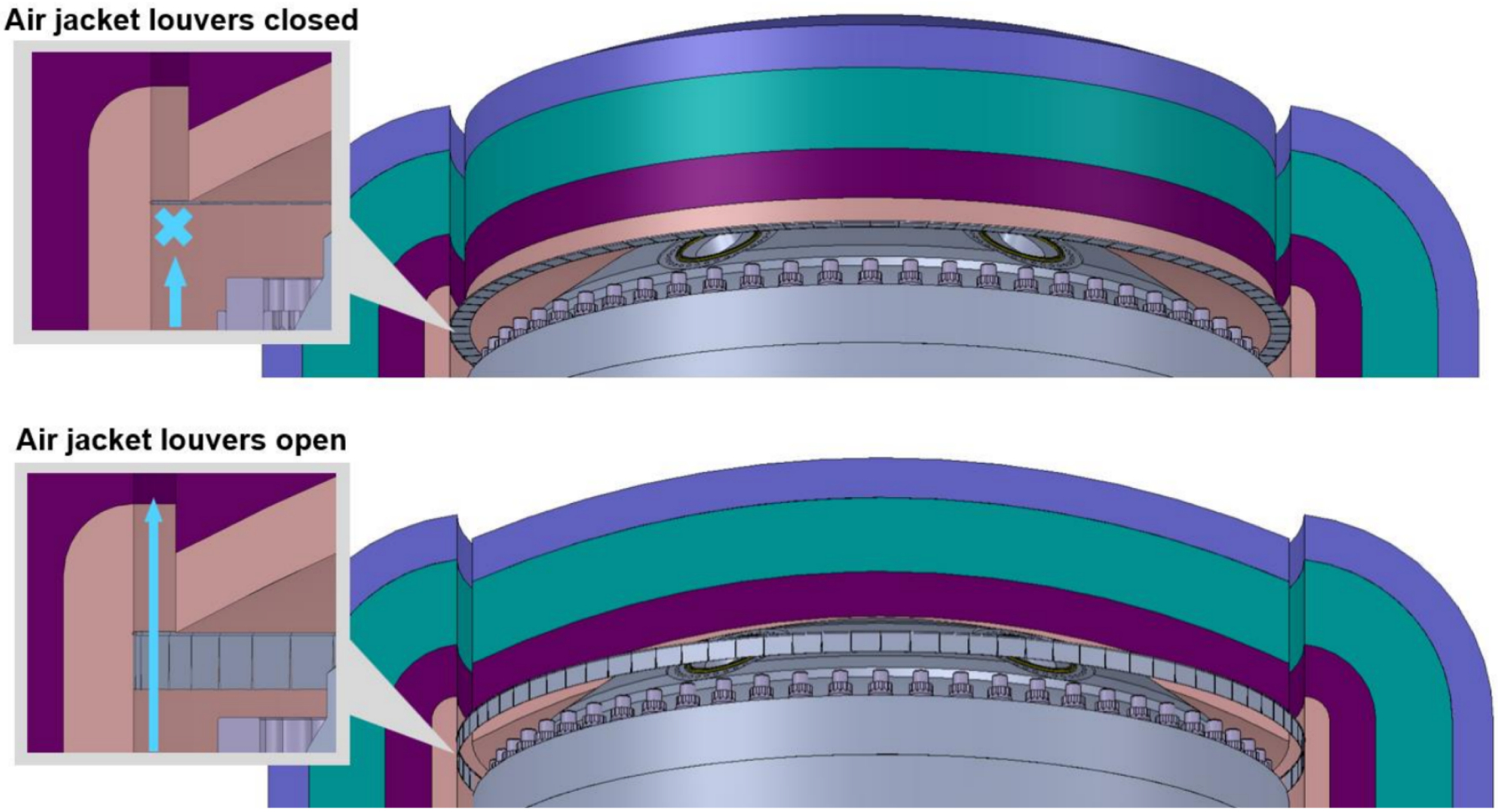
*Pictured for reference only, not actual design.

Primary Loop Design

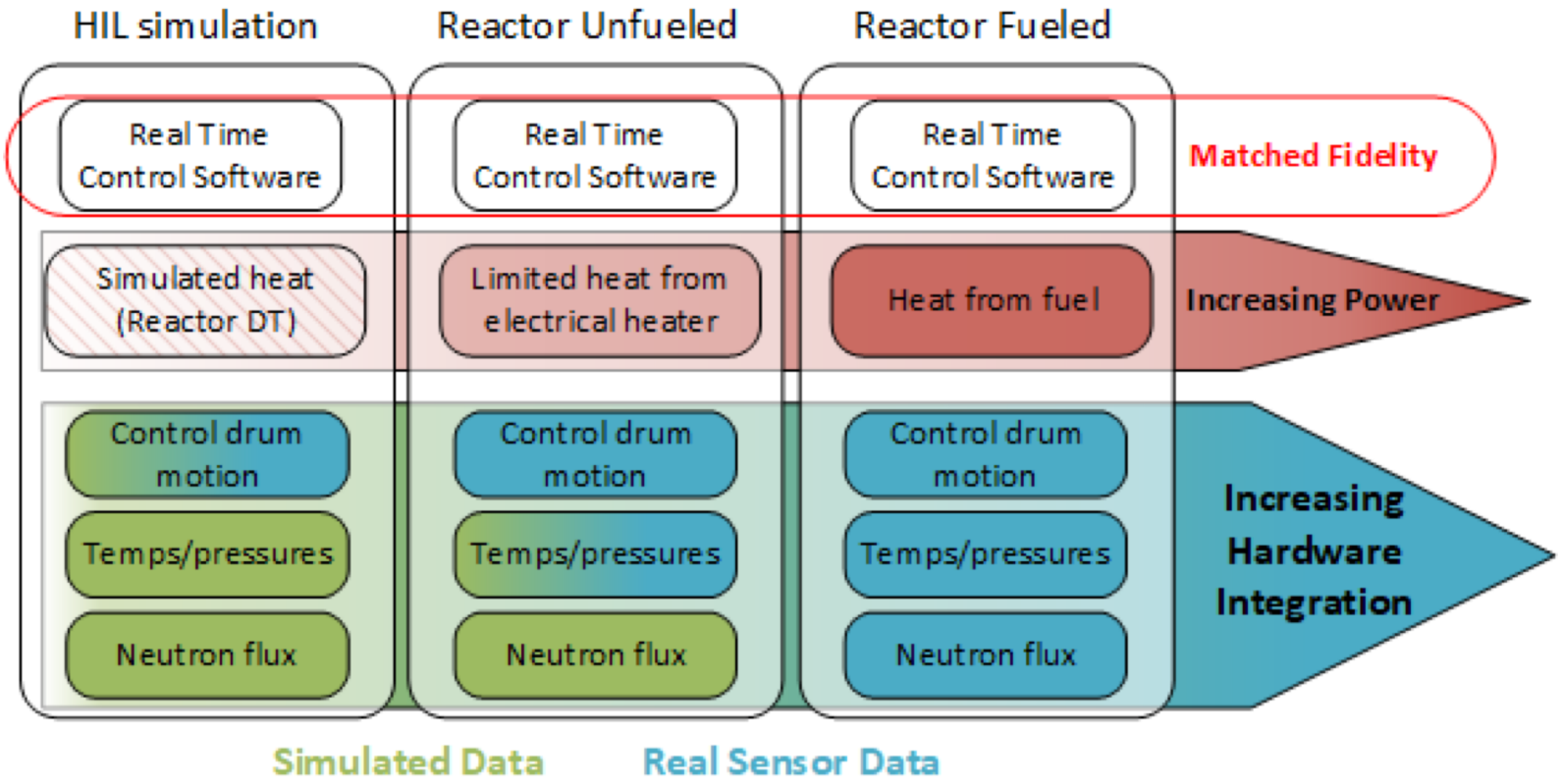


Primary Loop Helium Flow Path

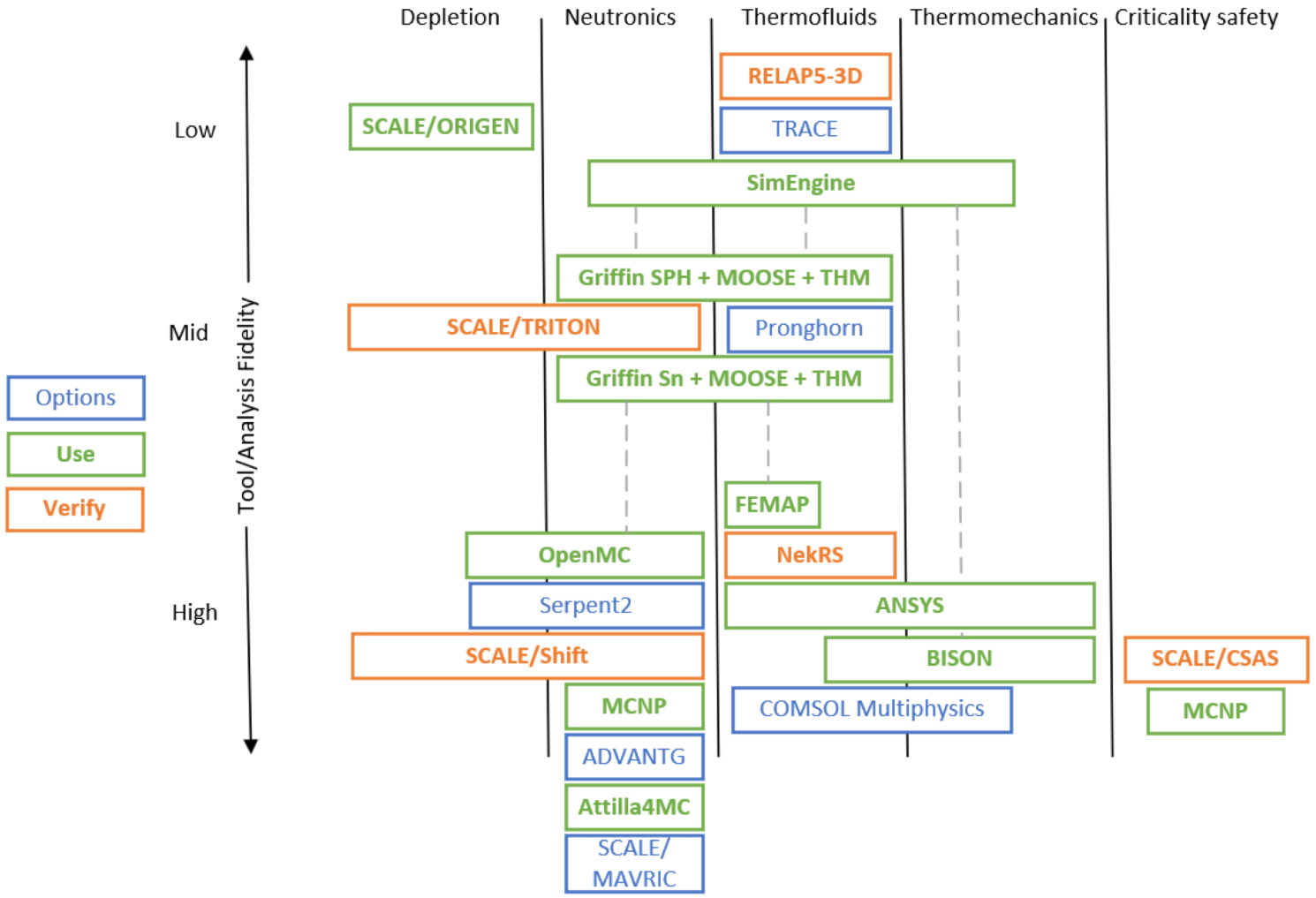
Air Jacket Design



Modeling and Simulation Methodology

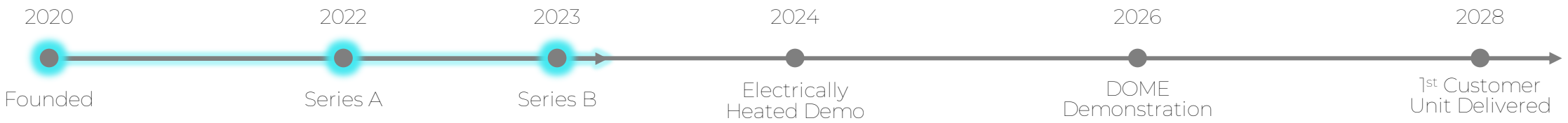


Modeling Methods and Tools



Kaleidos Demonstration Project

- Operate Kaleidos at 3.5 MWt for at least 1 week
- Tests reactor and primary loop in existing containment structure, only generates heat
- Qualification through demonstration: Unlocks commercialization



Q & A

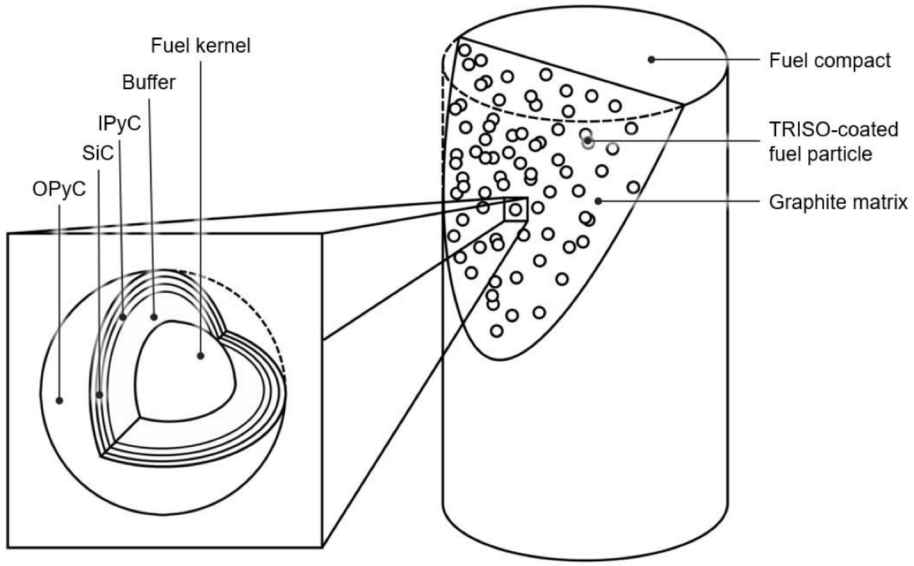
Supplemental Slides

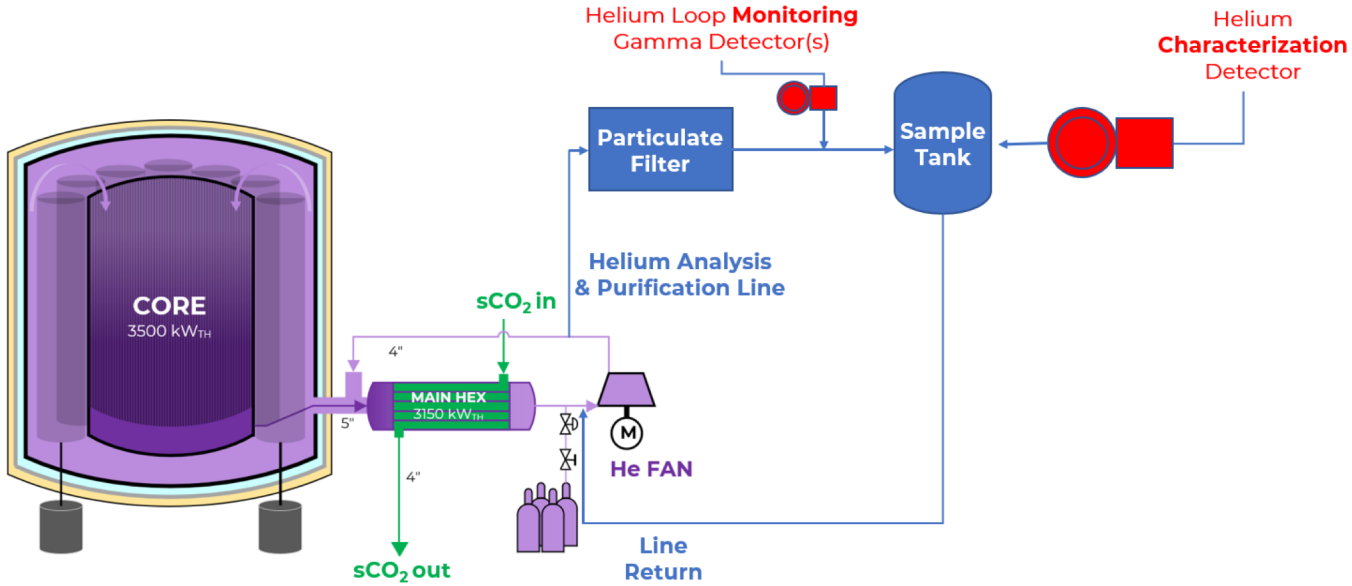
RADIANT

Analysis

Quantity of Interest	Method(s)	Purpose
Configuration criticality	MCNP	Initial critical configurations, reactivity worth
Excess reactivity & shutdown margin	OpenMC & MCNP	Condition reactivity worth measurements
Time-dependent decay heat	OpenMC & SCALE	Heat source for postulated scenarios
Time-dependent source term	OpenMC & SCALE	Radiological source for mechanistic source term evaluation
Power distribution	OpenMC	Power peaking factors
Control drum worth	OpenMC & MCNP	Safety margins, reactivity insertion rates, conditions for postulated scenarios
Temperature and other reactivity coefficients	OpenMC	For transient simulations
Steady-state coolant temperatures	SimEngine	Initial conditions for postulated scenarios
Time-dependent core temperature during loss of coolant/flow	SimEngine & ANSYS	Margin to fuel, moderator, and steel limits
Fuel thermomechanical performance	BISON	Failure probability/margin

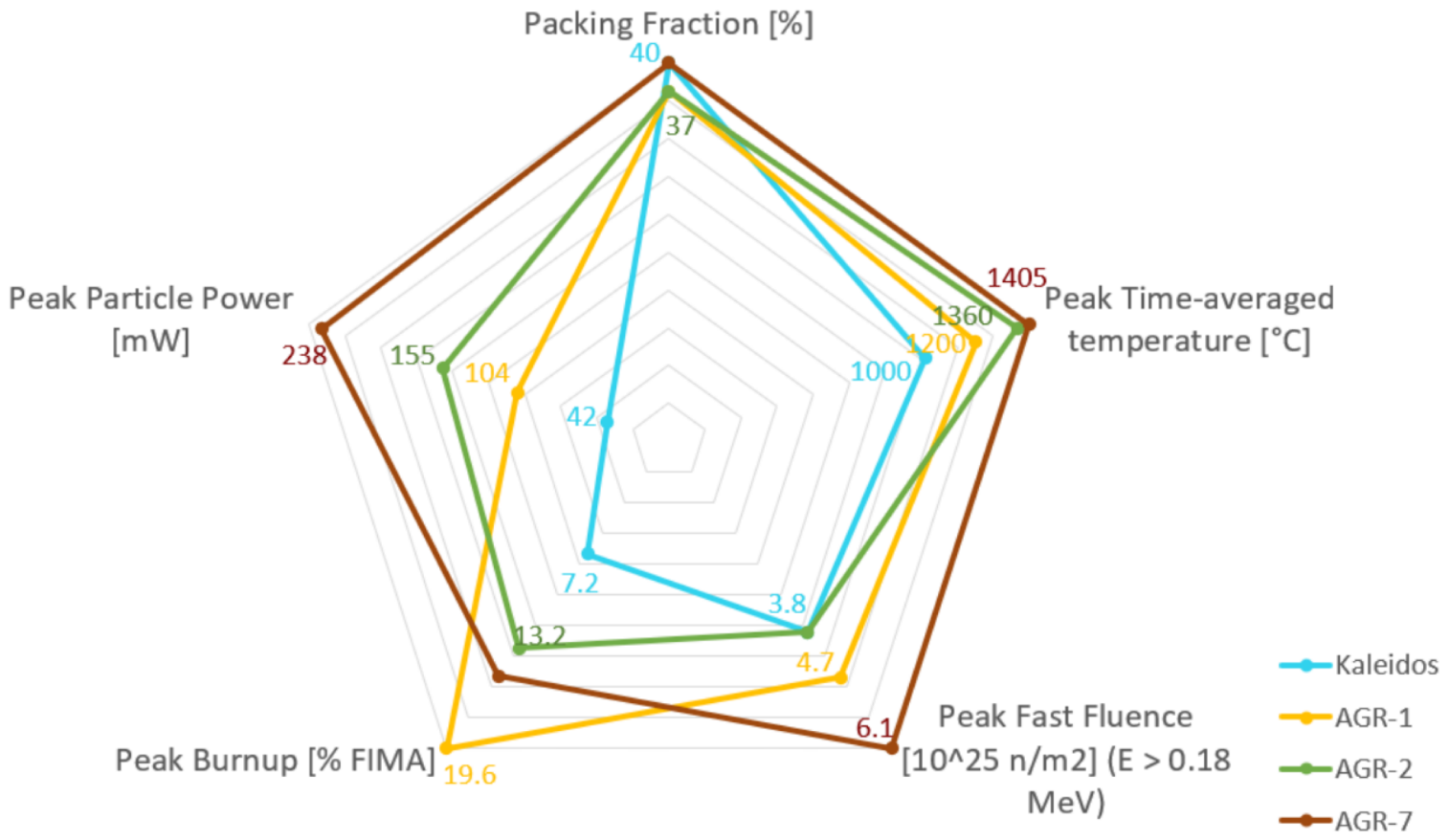
Kaleidos Fuel





Helium loop radionuclide monitoring and characterization components in flow loop.

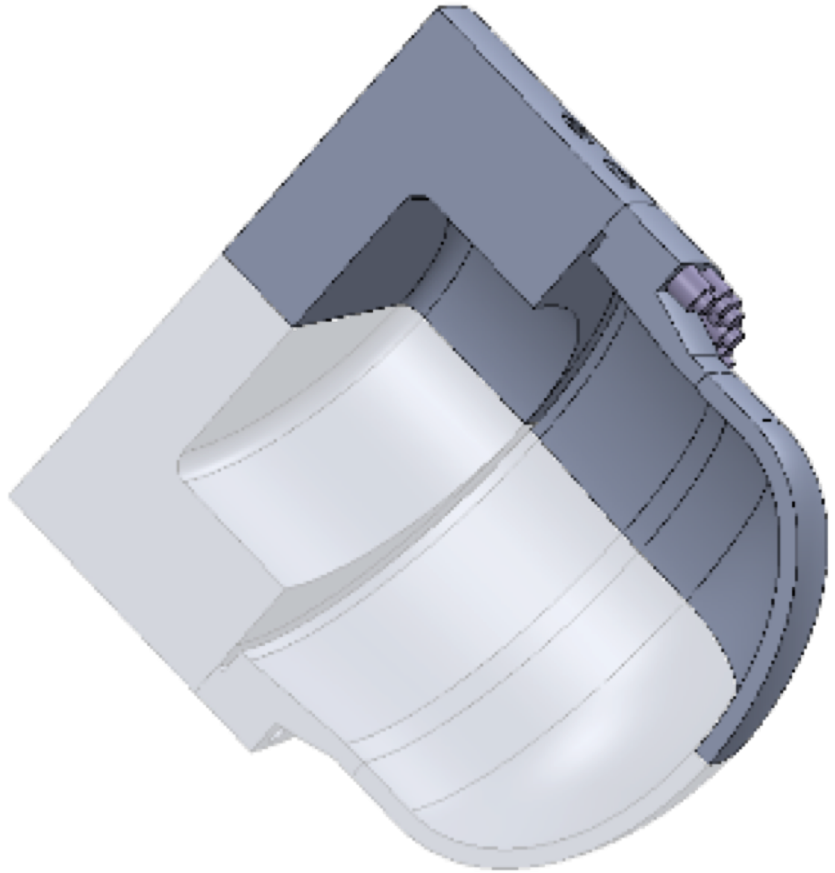
Kaleidos Fuel Performance Envelope



Pressure Vessel Milestones

- SS-316H ingot produced
- Completed custom tooling for forging
- Designed seal test unit to validate high temperature seal leak rates and bolted joint performance

Our SS-316H ingot.



High temperature seal test unit.

Structural Graphite Milestones

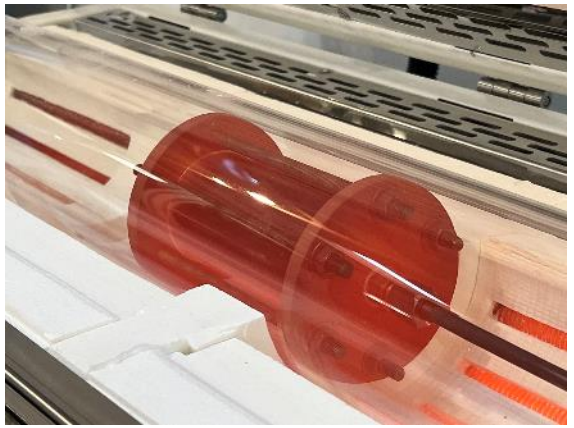
- 4.5 tons of PCEA billets
- Ordered consumer grade graphite for the electrically heated demonstration build
- Fabricated test units with multiple vendors to assess as-built tolerances

PCEA graphite from AGM

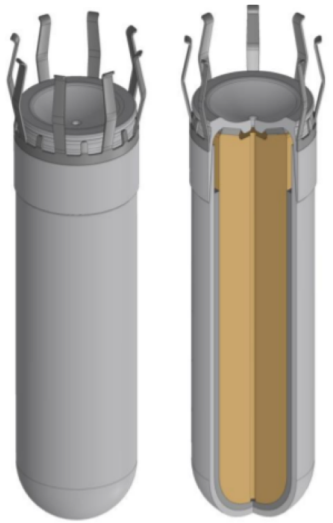
Graphite machining tests.

Zirconium Hydride Production Milestones

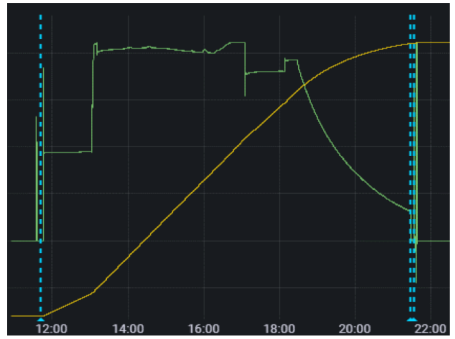
- Multiple successful runs to saturated beta phase, verifying setup and absorption rate
- Target H/Zr atomic ratio of 1.0, achieved atomic ratio of 0.992
- Identified max hydriding speed by increasing flow until diffusion rate was limited by zirconium



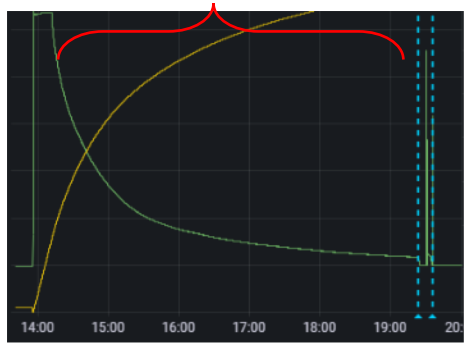
Red-hot hydriding chamber (zirconium slug sits inside of this).



Zirconium post-hydriding.

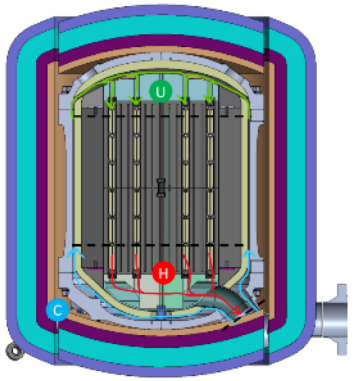


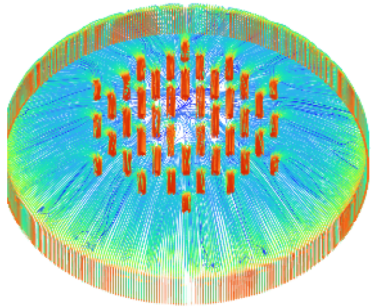
Diffusion Rate Limited

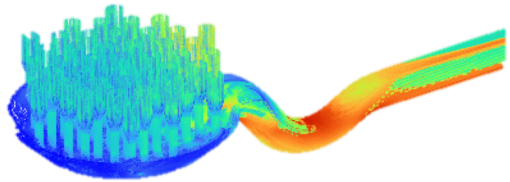


Primary Loop Milestones

- Computational Fluid Dynamics
  - Used to refine internal reactor geometry
  - Methods for performing Multiphysics analysis of reactor core graphite are in development





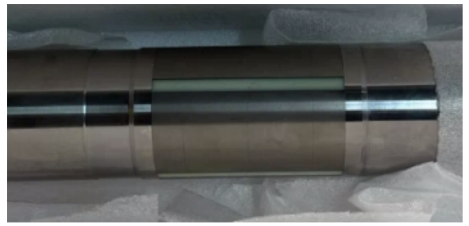


- Helium Circulator In Fabrication


Impeller


Motor Housing


Motor Shaft Before Magnets


Motor Shaft with Magnets


Volute Casting