



Cold Critical Pre-Experiment Simulations of KRUSTy

Kristin Smith*
Rene Sanchez, Ph.D.†

* University of Florida, Nuclear Engineering Program

† Los Alamos National Lab, Advanced Nuclear Technology

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Acknowledgement



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Introduction

- Overview
- Three main sections: fuel, reflector, shield
- Cold critical configuration
- Simulations and calculations
- Preliminary results for worth of BeO ring reflectors
- Estimates of heights needed for various configurations

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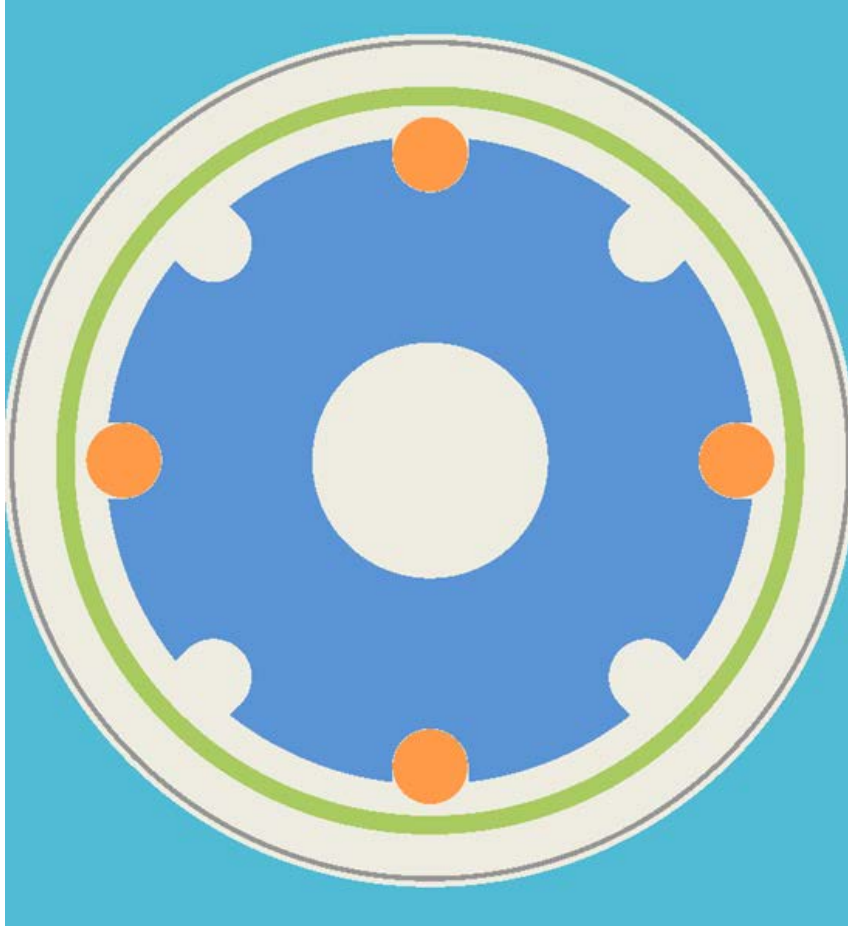
What is KRUSTy?

- Kilowatt Reactor Using Stirling Technology
- Designed to power space applications
- Mounted on Comet, a vertical assembly machine

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Fuel



- 93% HEU
- 8 wt.% molybdenum
- Eight slots for heat pipes or support rods

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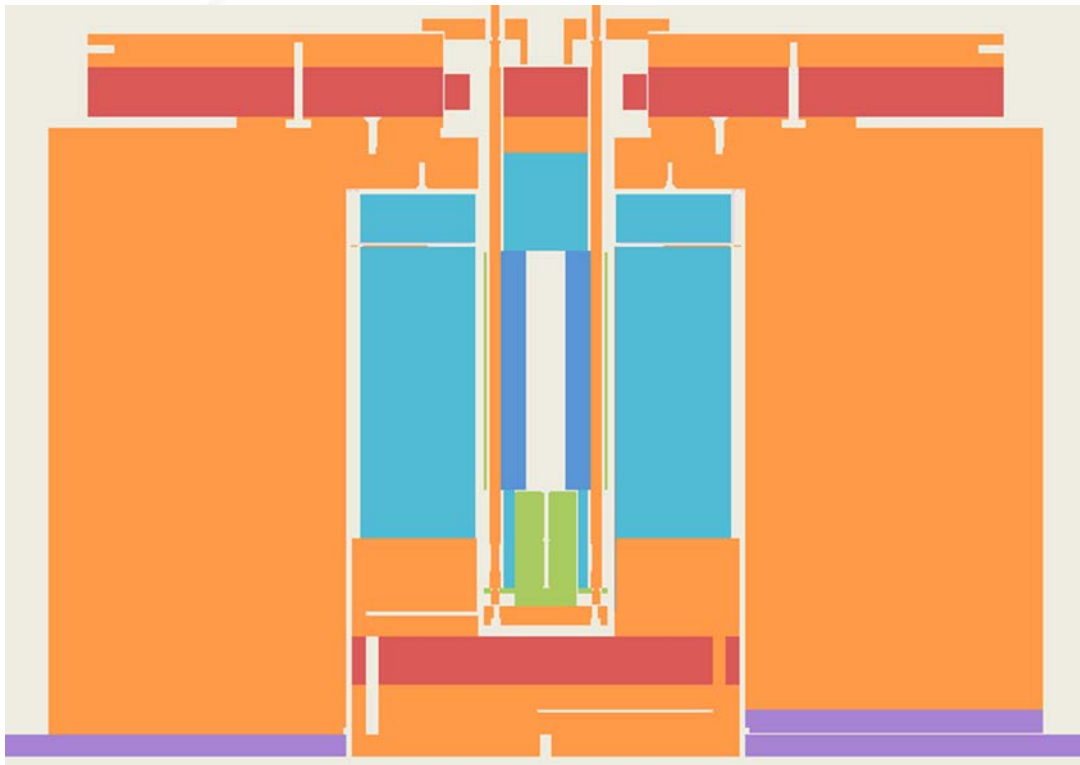
Reflector

- Beryllium Oxide (BeO)
- Three main zones
 - Top reflector
 - Bottom reflector
 - Ring reflector
- Height of ring reflector is variable



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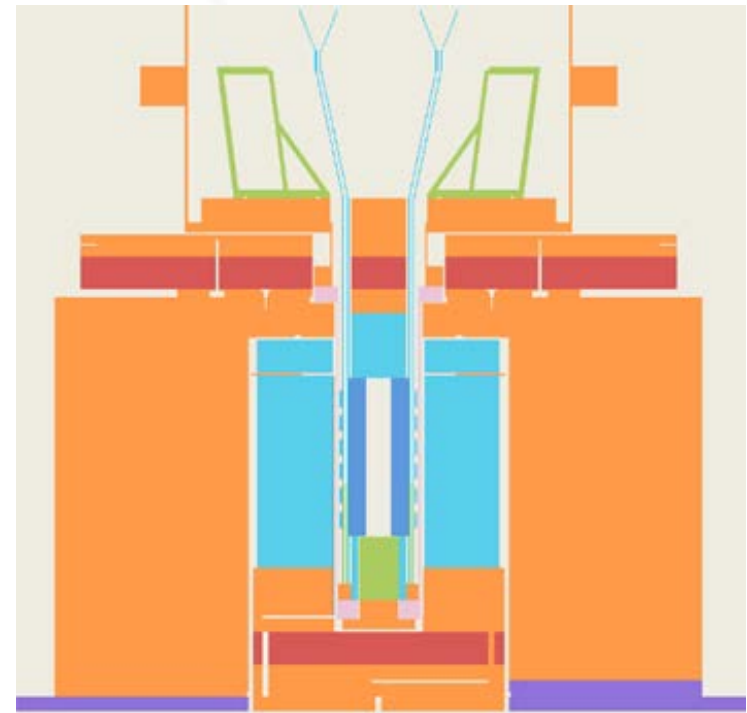
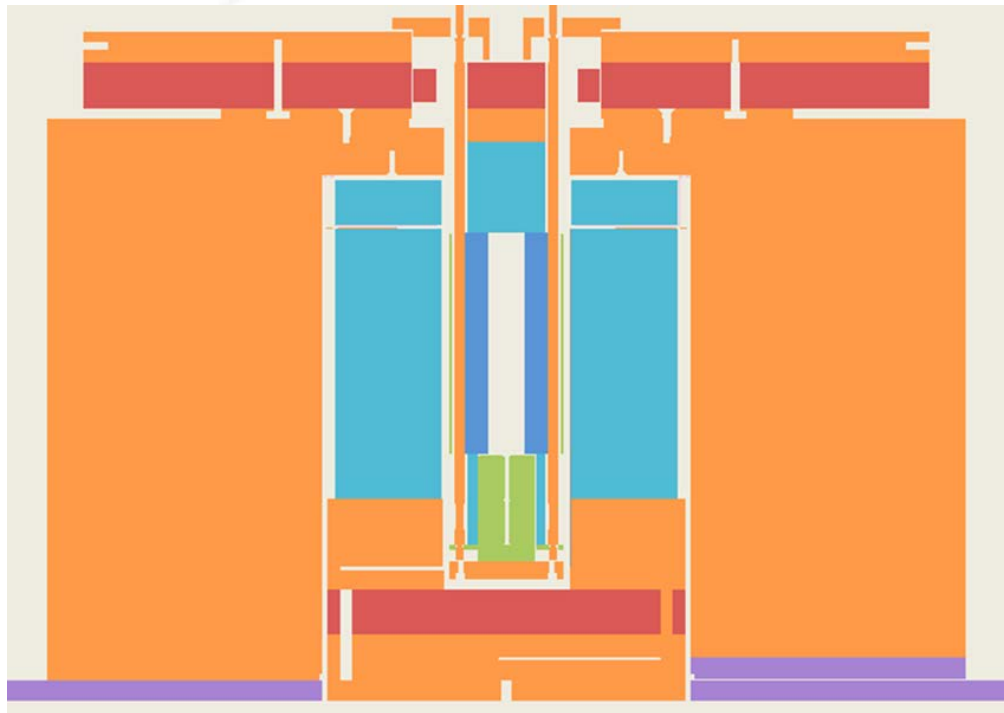
Shielding



- Stainless steel outer shield
- Multi-layered top shield with B_4C
- Multi-layered bottom shield with B_4C

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Differences



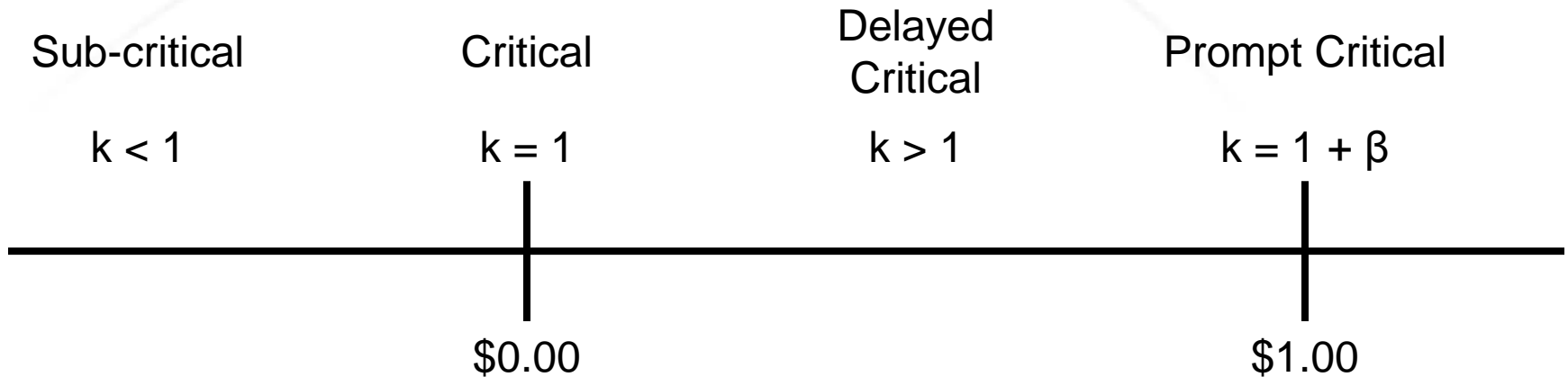
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Simulations

- Created KENO-VI and MCNP6 models
- Varied the heights of the ring reflectors
- Used various cross section libraries

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Reactivity Worth (\$)



$$\text{\$} \equiv \frac{\rho}{\beta_{eff}} = \frac{k_{eff} - 1}{k_{eff} \cdot \beta_{eff}}$$

β_{eff} of an HEU system is taken as 0.0065

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Average Reflector Height

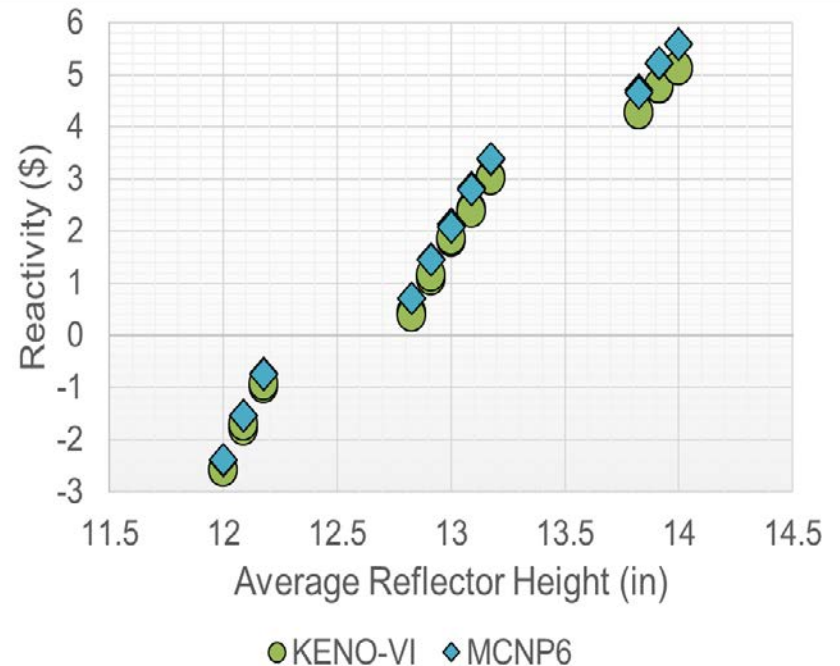
$$h = \frac{V}{A} = \frac{\pi [h_{inner} (r_{middle}^2 - r_{inner}^2) + h_{outer} (r_{outer}^2 - r_{middle}^2)]}{\pi (r_{outer}^2 - r_{inner}^2)}$$

- $r_{inner} = 7.2428$ cm
- $r_{middle} = 12.7$ cm
- $r_{outer} = 19.05$ cm
- h_{inner} and h_{outer} vary based upon configuration

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Code Comparison

KENO-VI k_{eff}	MCNP6 k_{eff}	Percent Difference
0.98349 ± 0.00026	0.98458 ± 0.00023	0.110707
0.98848 ± 0.00024	0.99011 ± 0.00023	0.164628
0.99367 ± 0.00025	0.99532 ± 0.00024	0.165776
1.00282 ± 0.00025	1.00459 ± 0.00024	0.176191
1.00712 ± 0.00025	1.00956 ± 0.00024	0.241689
1.01195 ± 0.00025	1.01410 ± 0.00025	0.212011
1.01603 ± 0.00025	1.01881 ± 0.00024	0.272867
1.02015 ± 0.00026	1.02243 ± 0.00024	0.222998
1.02853 ± 0.00027	1.03149 ± 0.00024	0.286964
1.03188 ± 0.00024	1.03501 ± 0.00029	0.302413
1.03439 ± 0.00025	1.03766 ± 0.00024	0.315132

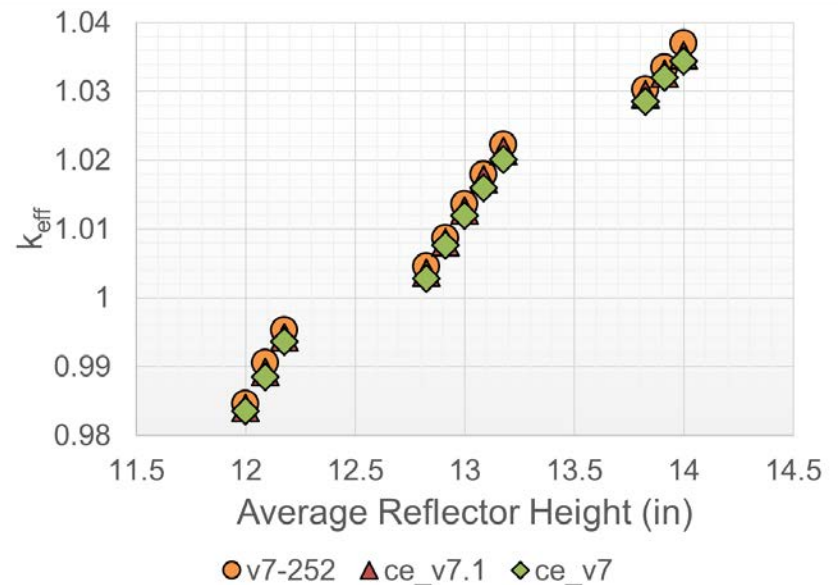


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Cross Section Library Comparison

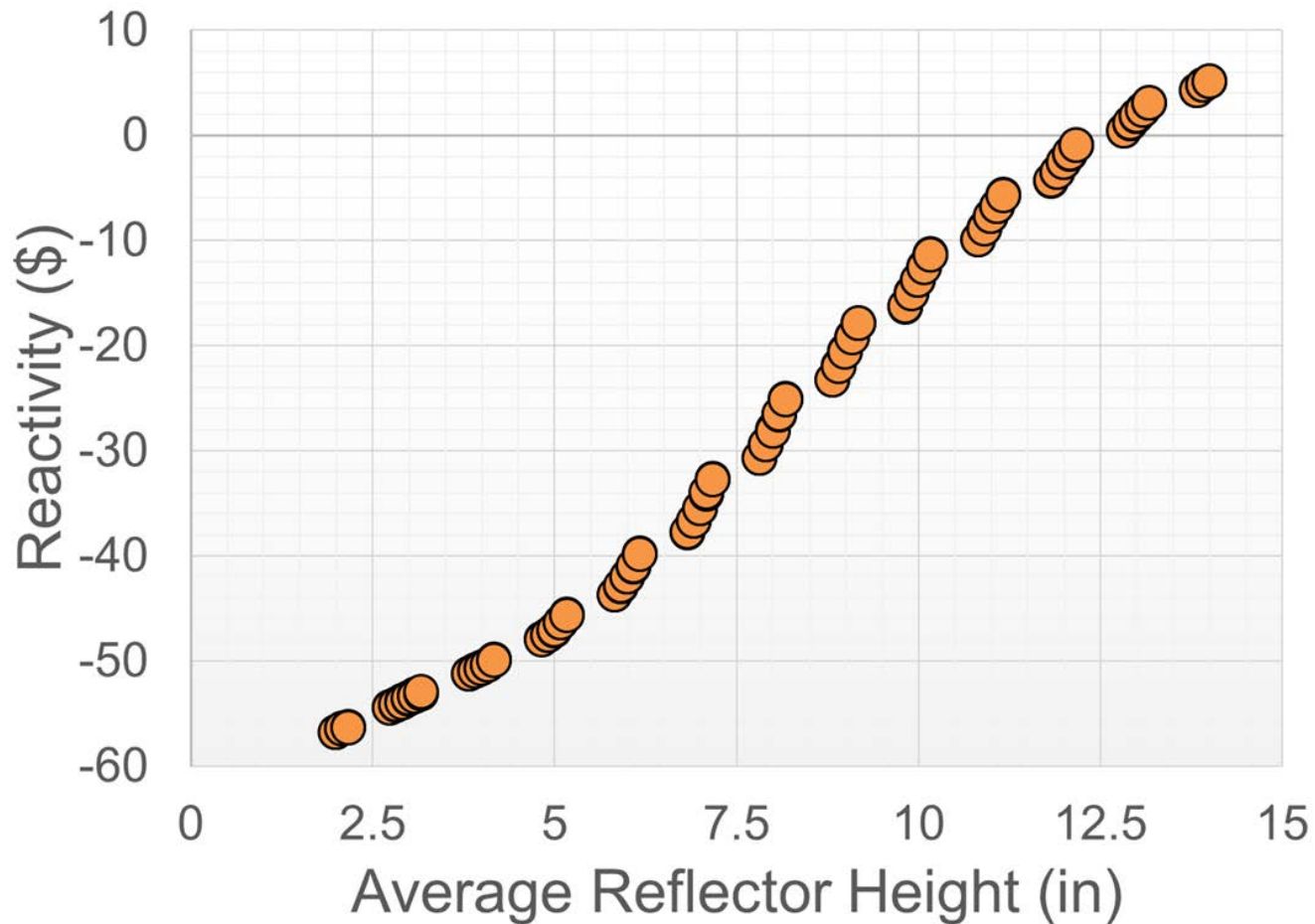
ENDF/B – VII 252 multi-group k_{eff}	ENDF/B – VII.1 continuous energy k_{eff}	ENDF/B – VII continuous energy k_{eff}
0.98462 ± 0.00024	0.98394 ± 0.00026	0.98351 ± 0.00027
0.99056 ± 0.00026	0.98927 ± 0.00025	0.98848 ± 0.00024
0.99535 ± 0.00024	0.99431 ± 0.00026	0.99367 ± 0.00025
1.00458 ± 0.00025	1.00368 ± 0.00026	1.00282 ± 0.00025
1.00866 ± 0.00025	1.00802 ± 0.00025	1.00765 ± 0.00024
1.01358 ± 0.00024	1.01275 ± 0.00024	1.01195 ± 0.00025
1.01795 ± 0.00027	1.01724 ± 0.00027	1.01603 ± 0.00025
1.02228 ± 0.00026	1.02134 ± 0.00026	1.02015 ± 0.00026
1.03031 ± 0.00026	1.02959 ± 0.00025	1.02853 ± 0.00027
1.03352 ± 0.00025	1.03254 ± 0.00027	1.03206 ± 0.00025
1.03700 ± 0.00023	1.03529 ± 0.00024	1.03439 ± 0.00025



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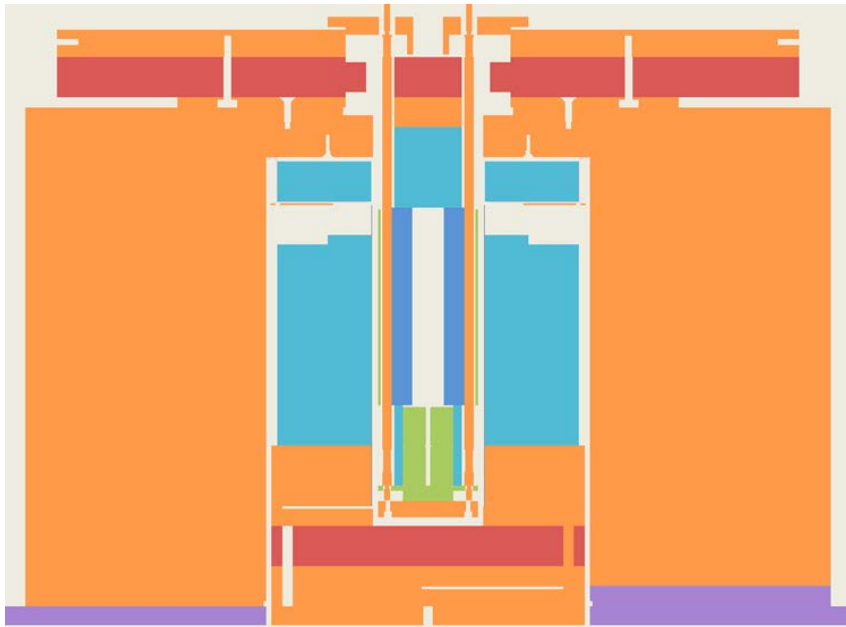
Reactivity vs. Average Reflector Height



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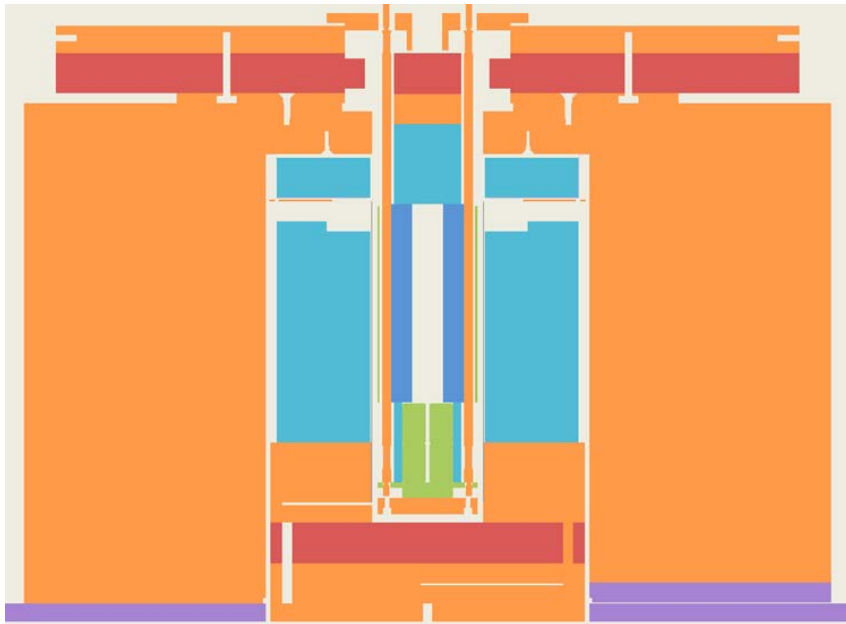
Subcritical Configuration



- $k_{\text{eff}} = 0.99367 \pm 0.00025$
- Inner reflector height = 31.75 cm
- Outer reflector height = 30.48 cm

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Delayed Critical Configuration



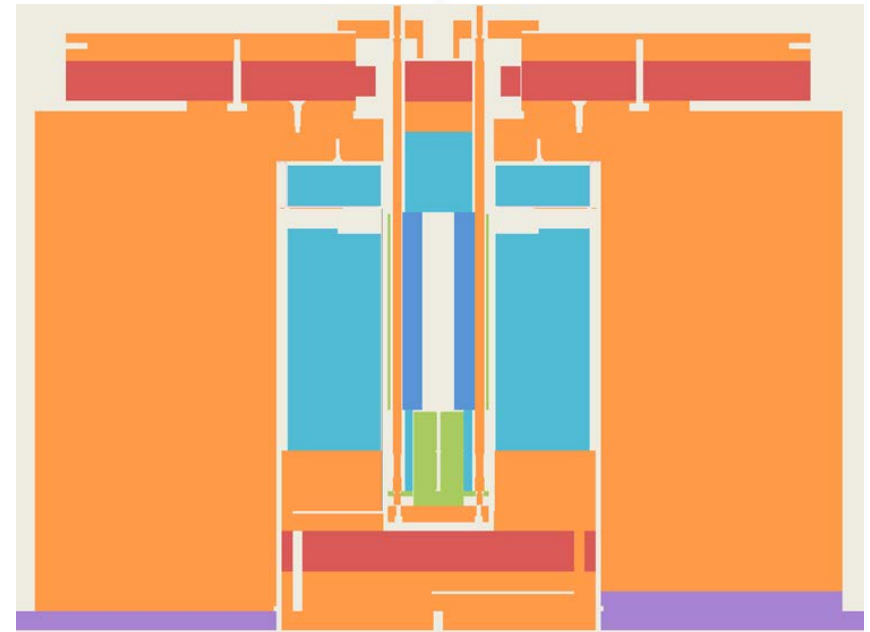
- $k_{\text{eff}} = 1.00282 \pm 0.00025$
- Inner reflector height = 31.75 cm
- Outer reflector height = 33.02 cm

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Prompt Critical Configuration

- $k_{\text{eff}} = 1.00712 \pm 0.00025$
- Inner reflector height = 32.385 cm
- Outer reflector height = 33.02 cm

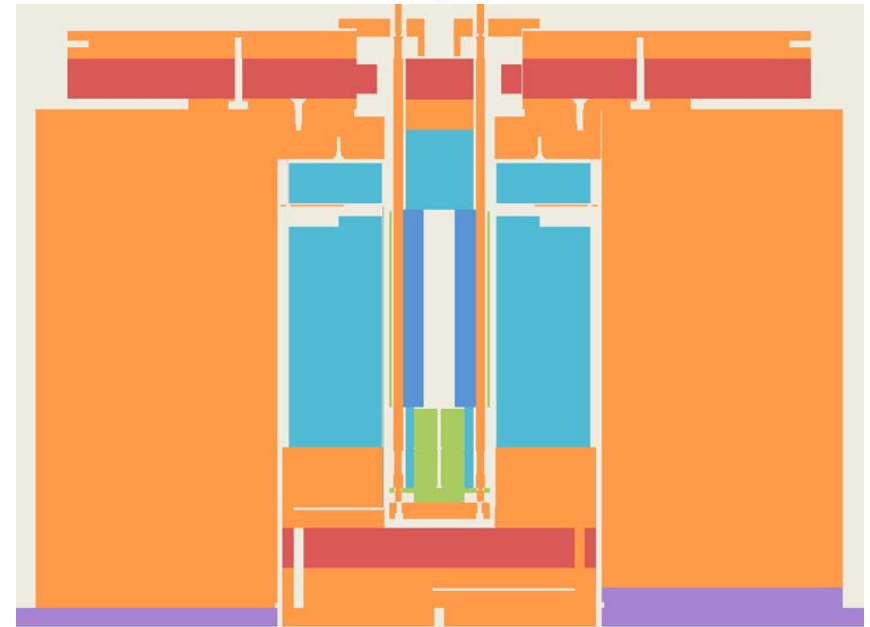


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\$3-Excess-Reactivity Configuration

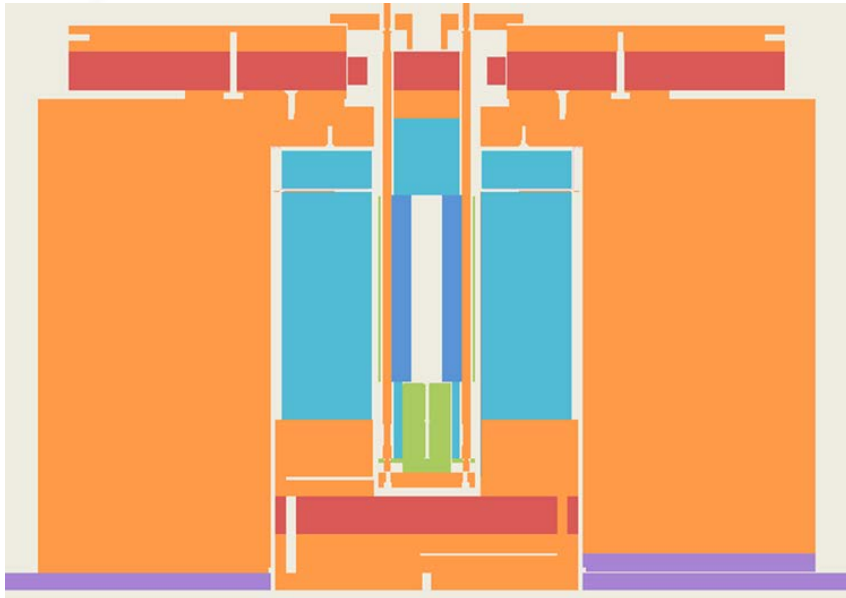
- $k_{\text{eff}} = 1.02015 \pm 0.00026$
- Inner reflector height = 34.29 cm
- Outer reflector height = 33.02 cm



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Fully Inserted Configuration



- $k_{\text{eff}} = 1.03439 \pm 0.00025$
- Inner reflector height = 35.56 cm
- Outer reflector height = 35.56 cm

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Results

- Average reflector ring worth of \$5.22/inch
- Delayed critical configuration:
 - 32.385 cm average reflector height
 - 1.00282 – 1.00459 k_{eff} range
- Prompt critical configuration:
 - 32.703 cm average reflector height
 - 1.00712 – 1.00956 k_{eff} range
- \$3-Excess-Reactivity configuration:
 - 33.655 cm average reflector height
 - 1.02015 – 1.02243 k_{eff} range

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Thanks for listening!

Any questions?

Kristin Smith

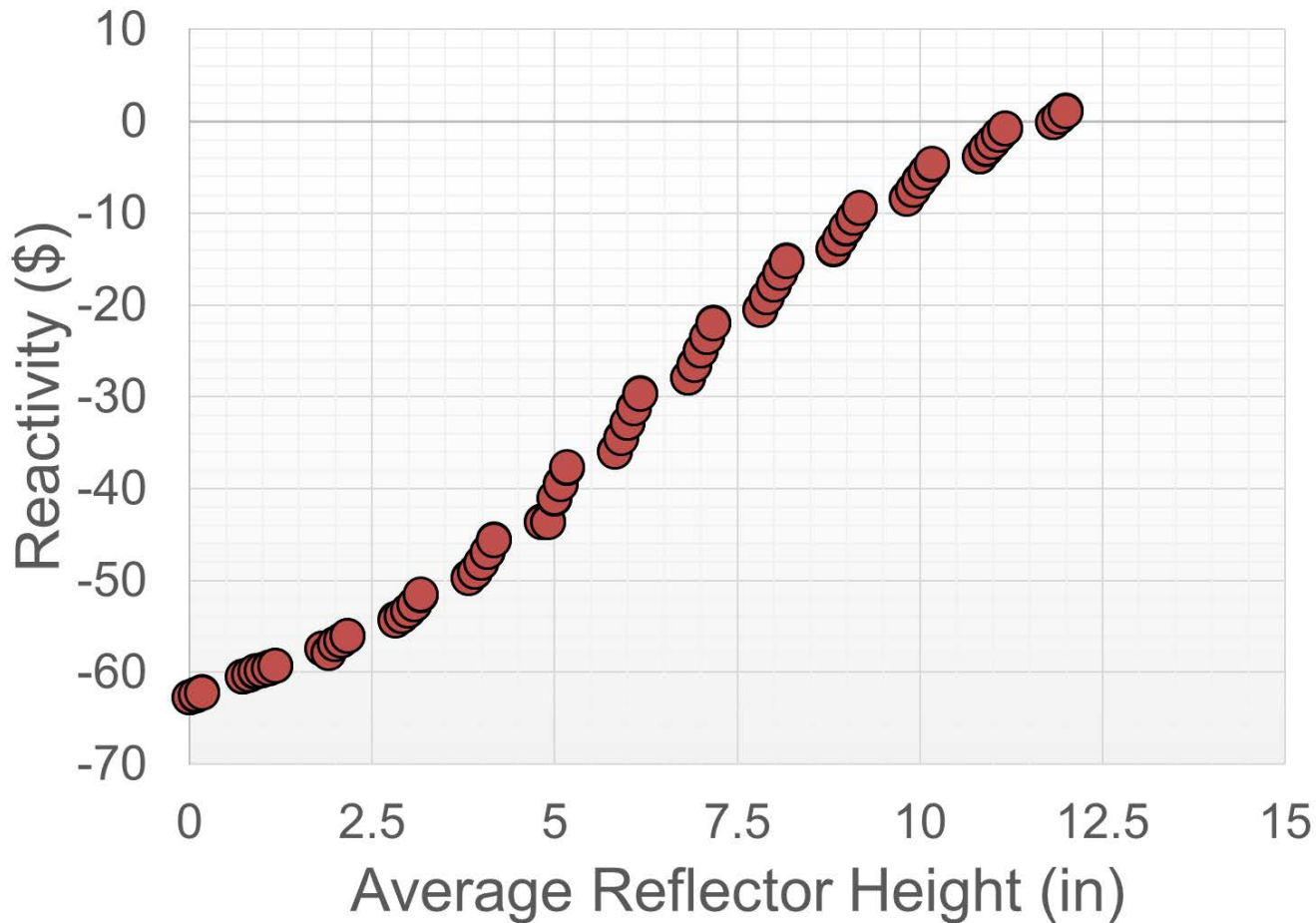
kristinnsmith@ufl.edu

Rene Sanchez

rgsanchez@lanl.gov

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Reactivity vs. Average Reflector Height



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