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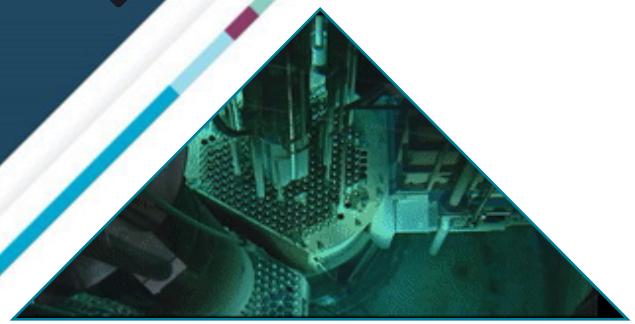

UPDATES ON UO_2-BeO EXPERIMENT (IER-523)

Mac Cook, Elijah Lutz, Andrés Morell-Pacheco, David Ames, John Miller, and James Cole

2024 DOE Nuclear Criticality Safety Program Technical Program Review

February 20-22, 2024

Hosted by Brookhaven National Laboratory

MAKING HISTORY, SHAPING THE FUTURE

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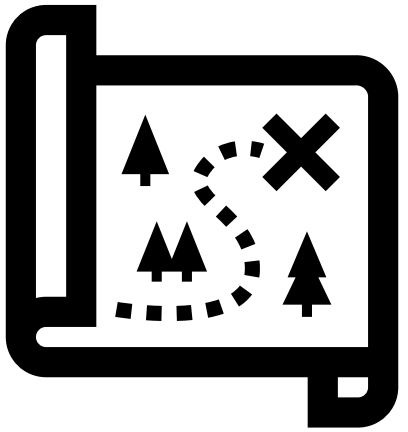
SAND2024-01393PE

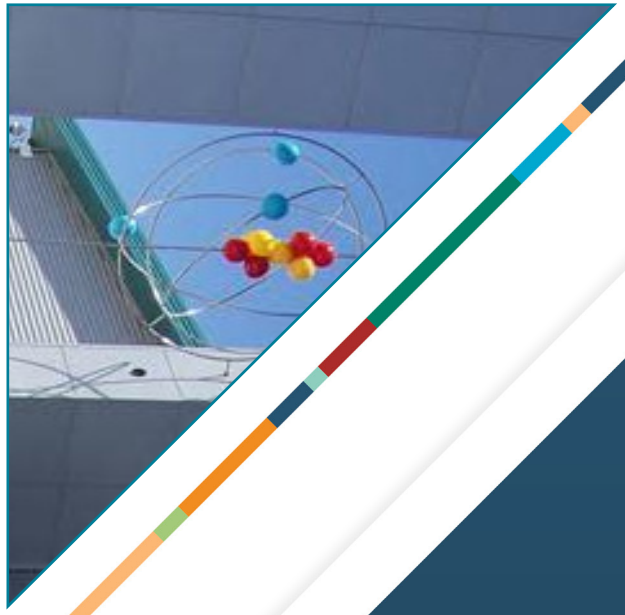
OUTLINE

- Experiment Status
- Experiment Motivation
- CED-1 Summary
- Current Efforts (CED-2)
- Concluding Summary

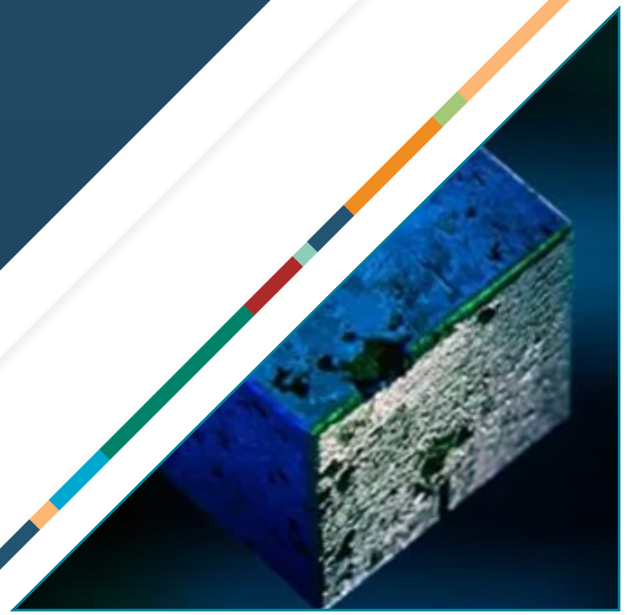


EXPERIMENT STATUS

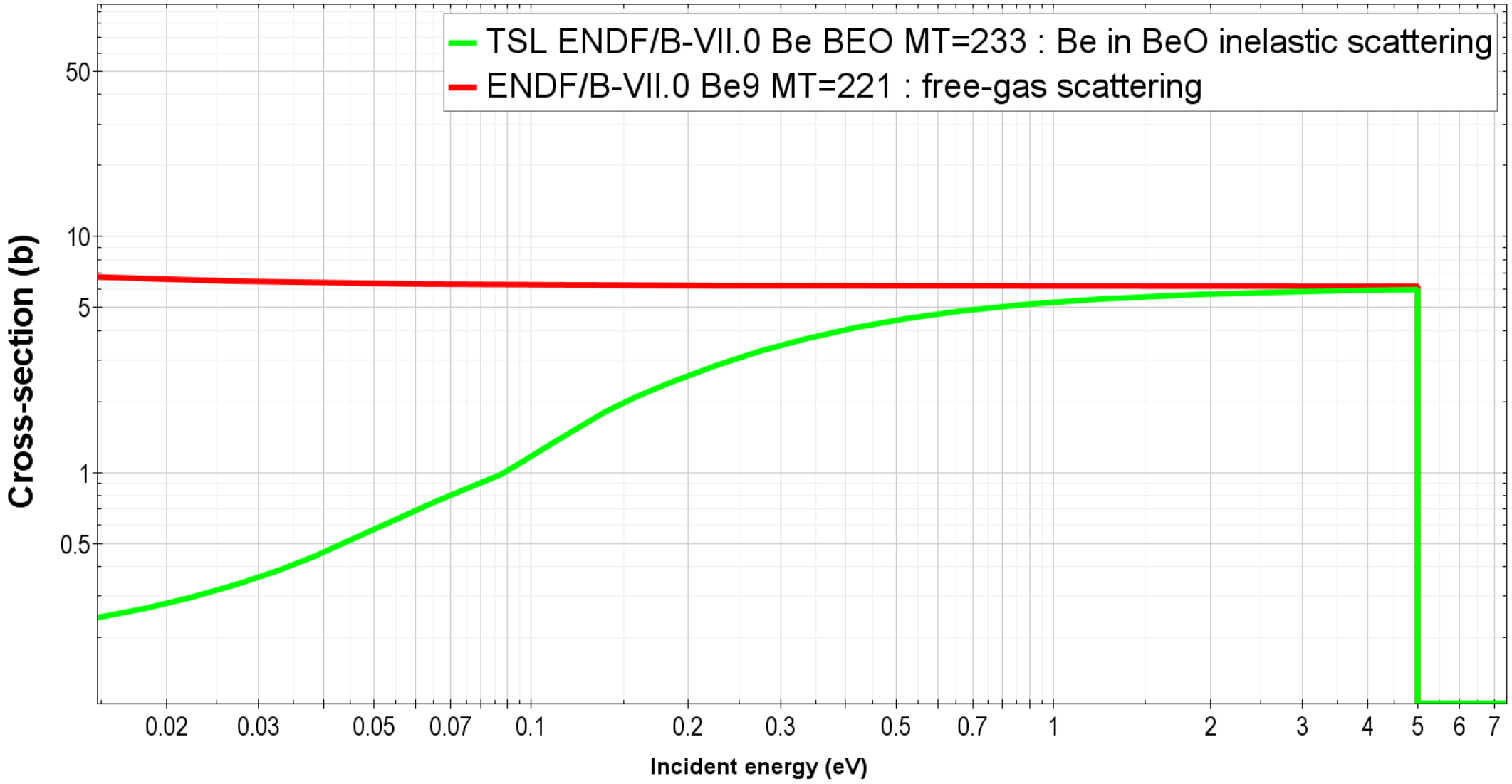
- Previously completed feasibility studies
  - Simple Designs
  - Parameter Sensitivities Included
- Completed CED-1 at end of FY23
  - Several Design Alternatives
- Currently performing CED-2
  - Maturation of Design



MOTIVATION



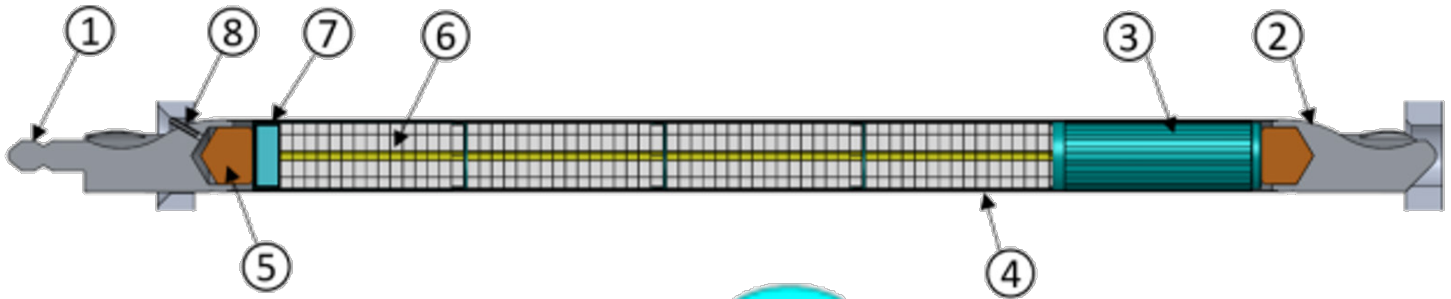
MOTIVATION


TSL ENDF/B-VII.0 Be BEO MT=233 : Be in BeO inelastic scattering
ENDF/B-VII.0 Be9 MT=221 : free-gas scattering
Cross-section (b)
50
10
5
1
0.5
0.02
0.03
0.05
0.07
0.1
0.2
0.3
0.5
0.7
1
2
3
4
5
6
7
Incident energy (eV)

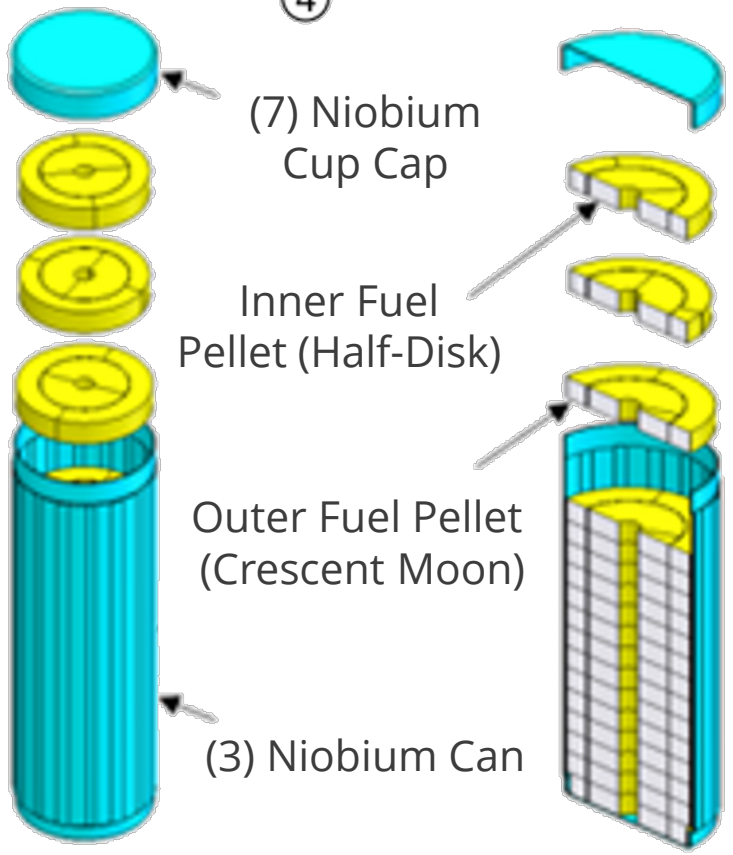
MOTIVATION - BACKGROUND

Sandia Critical Experiments

MOTIVATION - BACKGROUND



1	Top Fitting
2	Bottom Fitting
3	Fuel Cup
4	Stainless-Steel Cladding
5	BeO Reflector
6	UO_2-BeO Fuel Assembly
7	Fuel Cap
8	Fill Tube



Outer Fuel Pellet (Crescent Moon)

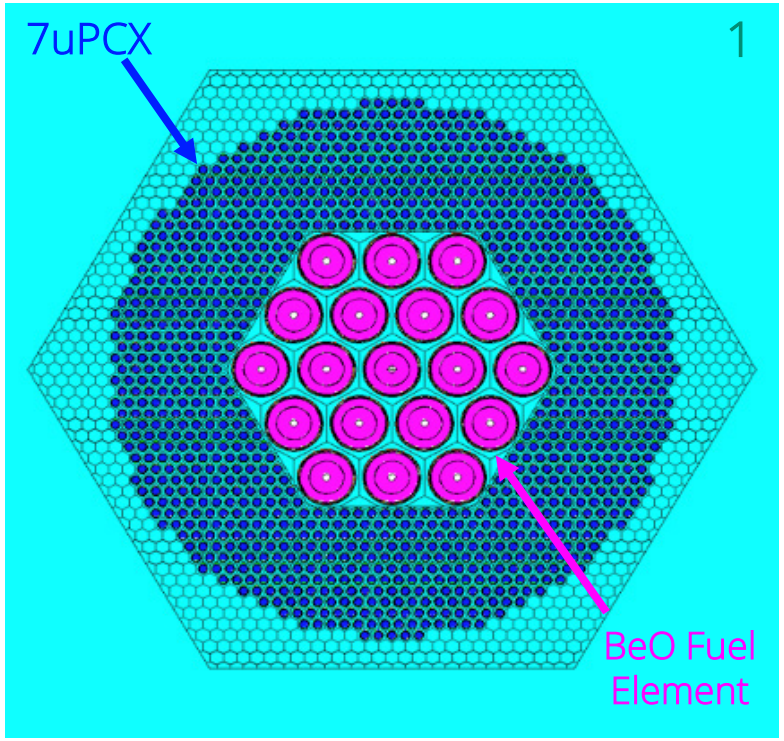
Inner Fuel Pellet (Half-Disk)

CED-1 SUMMARY

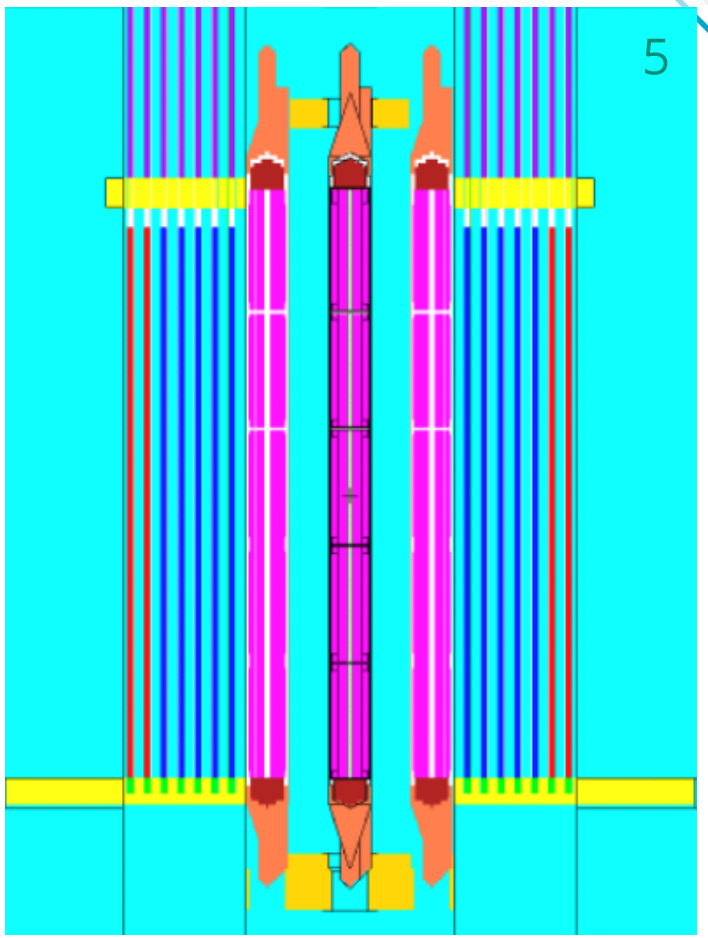
EXPERIMENT DESIGN – ELEMENT MODELS

Element Models

- Central test region containing 7 or 19 BeO fuel elements
- Driver region = 7uPCX fuel rods
  - Tight-packed
    (hex pitch = 0.86 cm)
  - Loose-packed
    (hex pitch = 1.72 cm)
- Fully reflected and water moderated
- Additional moderator/reflector configurations
  - Be metal rods
  - BeO rods

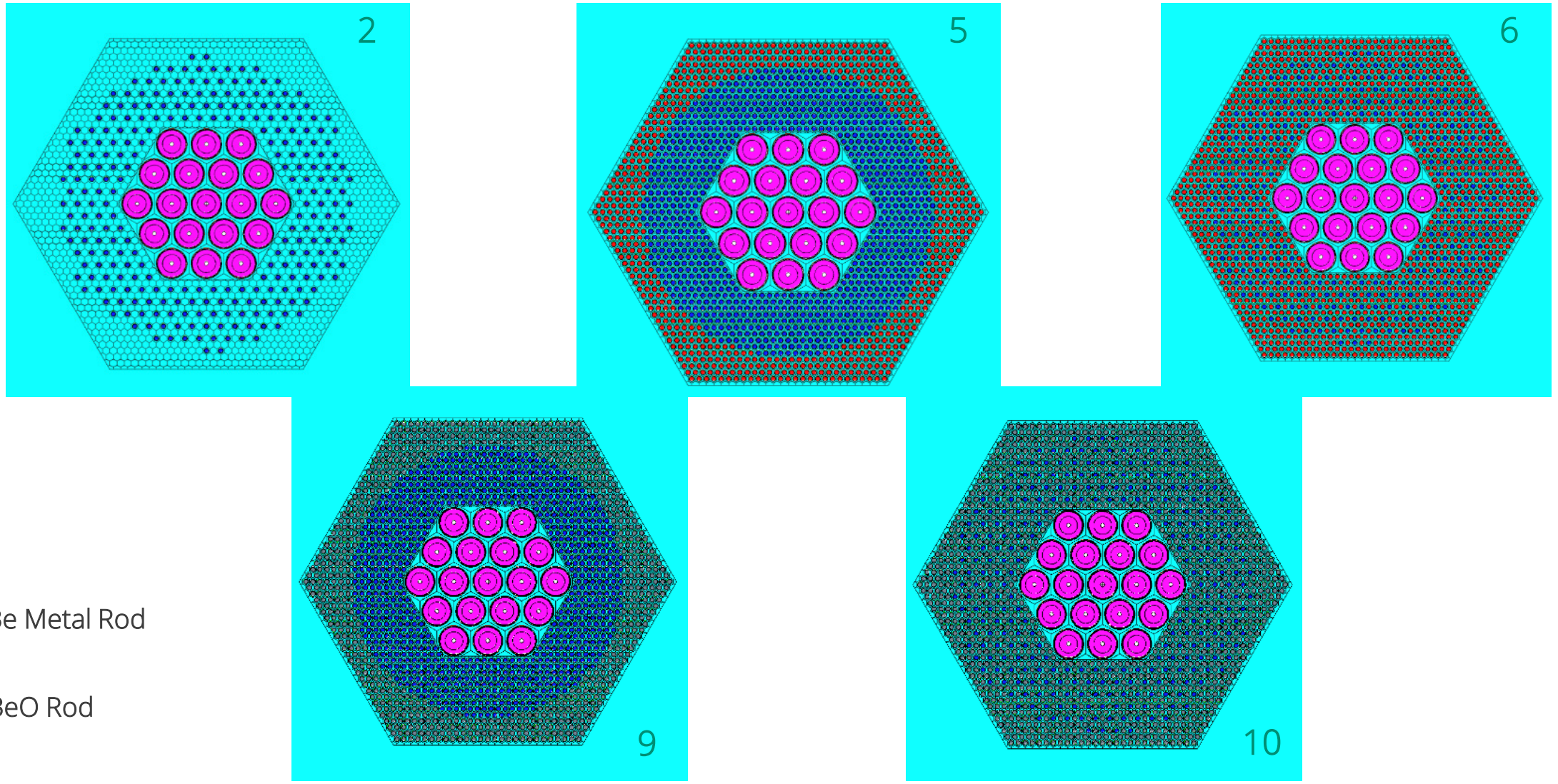


Top Cross Section View



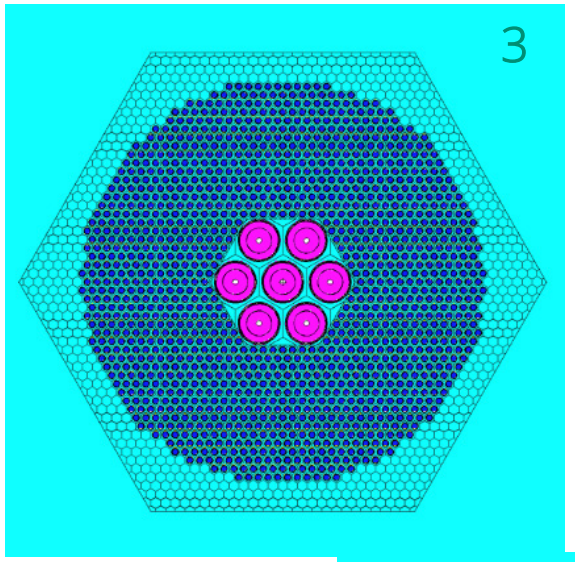
Side Cross Section View

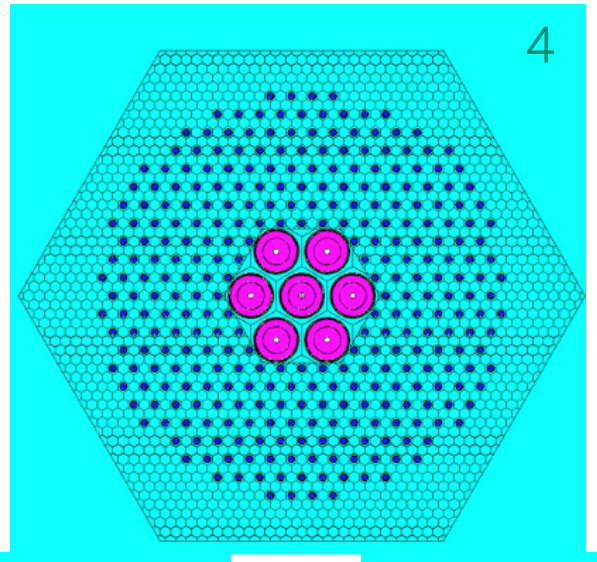
EXPERIMENT DESIGN – 19 BeO ELEMENT CONFIGURATIONS

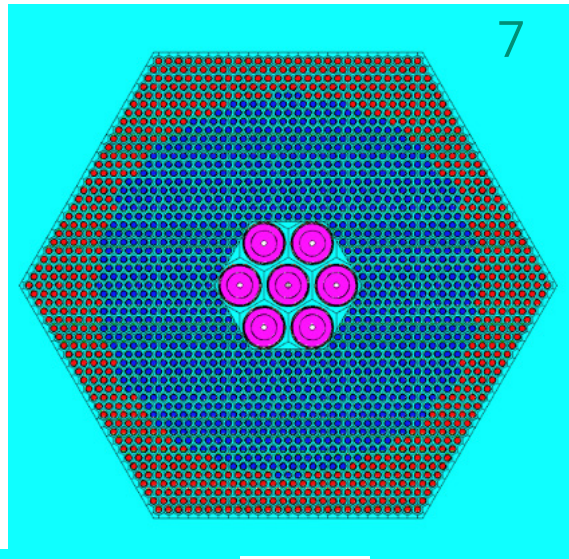


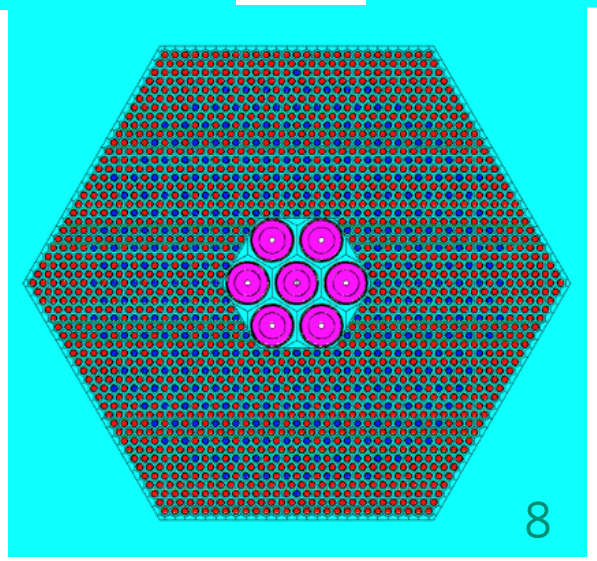
Radial Cross Section View

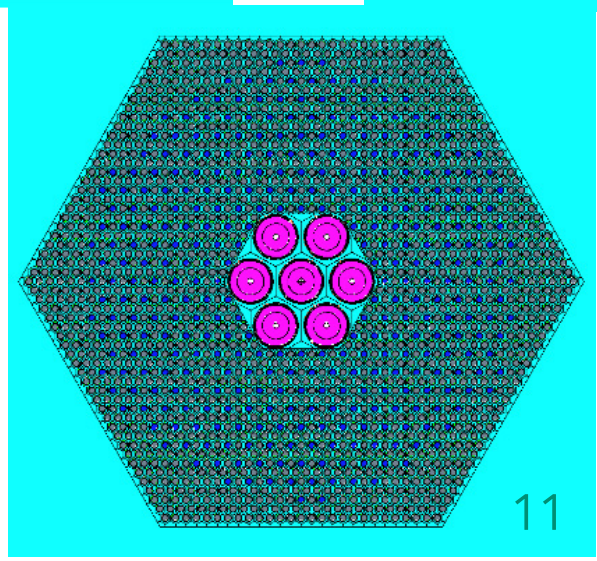
EXPERIMENT DESIGN – 7 BeO ELEMENT CONFIGURATIONS

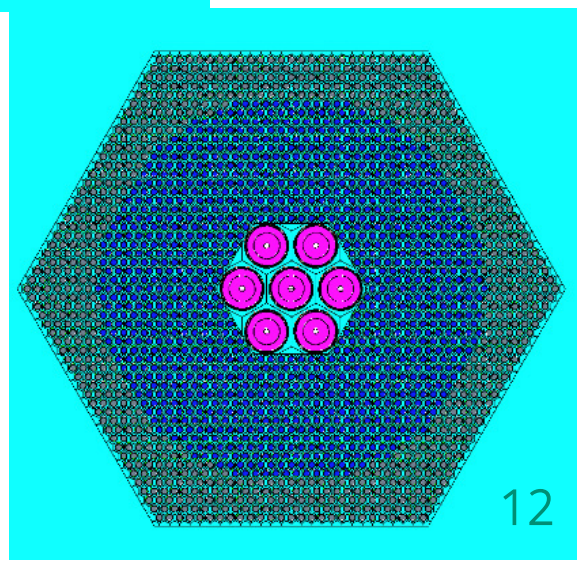












Be Metal Rod

BeO Rod

Radial Cross Section View

EXPERIMENT DESIGN – ELEMENT MODELS SUMMARY

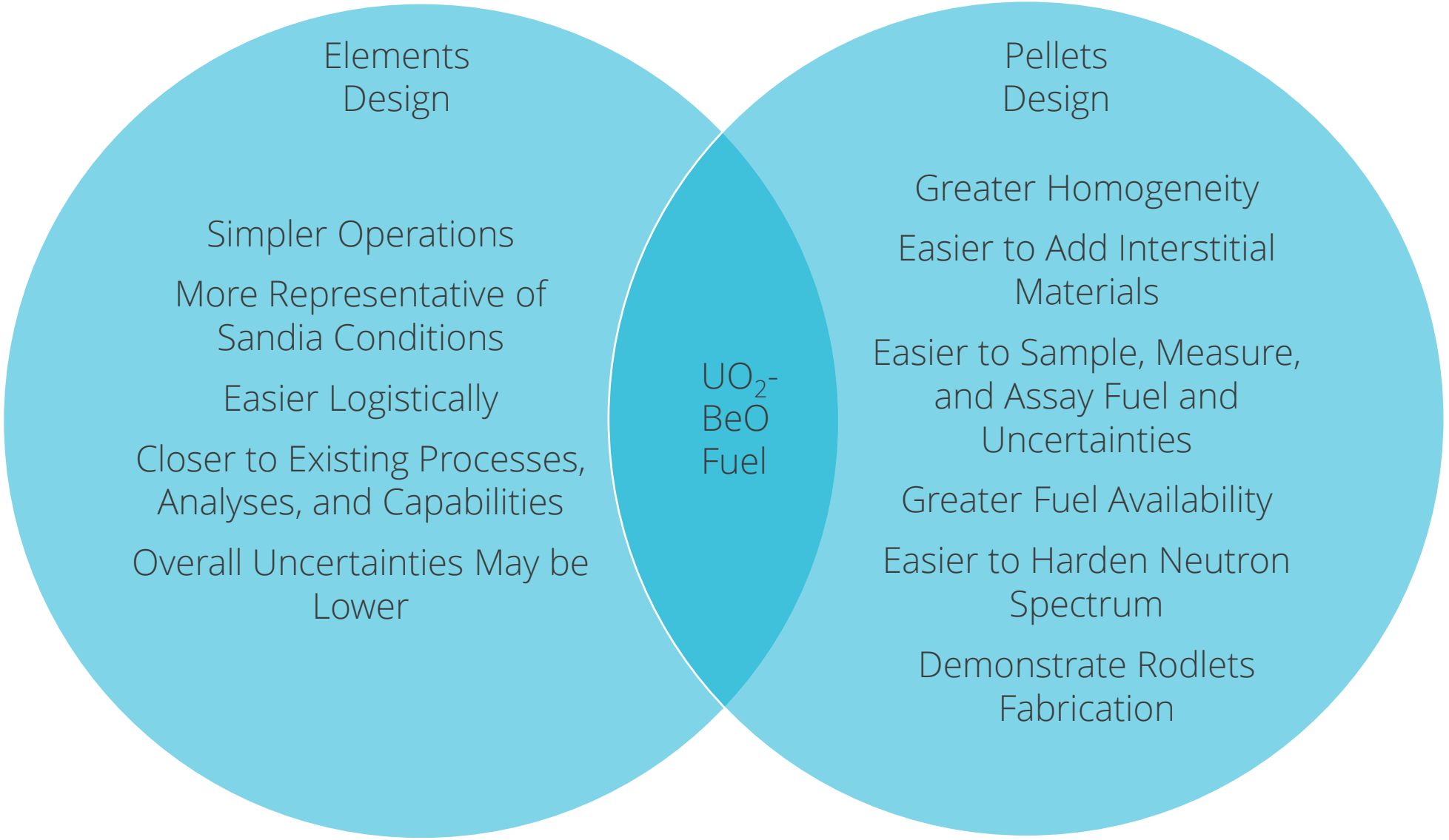
Config. #	# of 7uPCX	7uPCX Pitch (cm)	# of BeO Fuel	Ref. Rods	Mod. Rods	EANLF (MeV)	3-Group Fission Fractions		
							<0.625 eV	0.625 eV - 100 keV	>100 keV
1	1129	0.86	19	None	None	3.64E-07	78%	17%	5%
2	264	1.72	19	None	None	9.03E-08	91%	8%	2%
3	1368	0.86	7	None	None	4.37E-07	77%	17%	6%
4	313	1.72	7	None	None	7.48E-08	93%	6%	2%
5	925	0.86	19	Be	None	3.52E-07	79%	17%	5%
6	284	1.72	19	Be	Be	1.13E-07	88%	10%	2%
7	1154	0.86	7	Be	None	4.31E-07	77%	17%	6%
8	347	1.72	7	Be	Be	9.46E-08	90%	8%	2%
9	900	0.86	19	BeO	None	3.51E-07	79%	17%	5%
10	288	1.72	19	BeO	BeO	1.14E-07	88%	10%	2%
11	1134	0.86	7	BeO	None	4.33E-07	77%	17%	6%
12	357	1.72	7	BeO	BeO	9.58E-08	90%	8%	2%

REACTIVITY EFFECTS ANALYSIS

EC#	Void Central Region	Replace UO_2-BeO Fuel Elements with			
		Void	Al	Water	7uPCX Rods
1	-156	-115	-133	-194	13
2	-321	-262	-298	-362	28
3	-46	-33	-36	-46	8
4	-97	-75	-85	-106	8
5	-172	-123	-149	-208	15
6	-334	-260	-306	-375	16
7	-48	-35	-36	-43	9
8	-96	-72	-83	-103	5
9	-177	-128	-151	-213	15
10	-335	-264	-309	-382	1
11	-49	-36	-38	-45	9
12	-95	-73	-83	-104	3

*Values in 100's of pcm

ALTERNATIVE DESIGN – LOOSE PELLETS



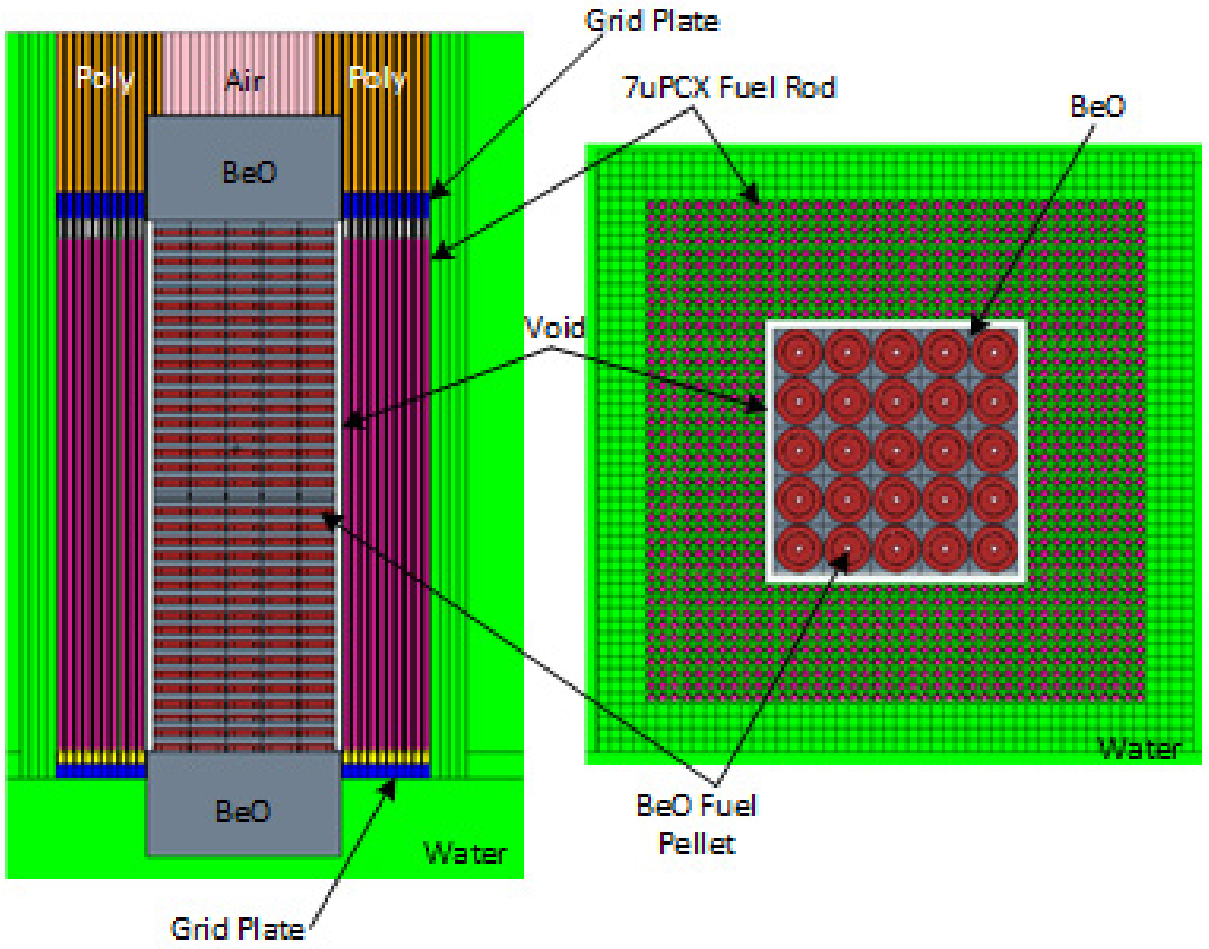
ALTERNATIVE DESIGN – LOOSE PELLET MODELS

- Central test region containing pellets in stacked cassettes
  - Each cassette is 5x5 array of cells
  - Cells are filled by sets of pellet pieces
- Many designs considered
    - Four presented in following slides

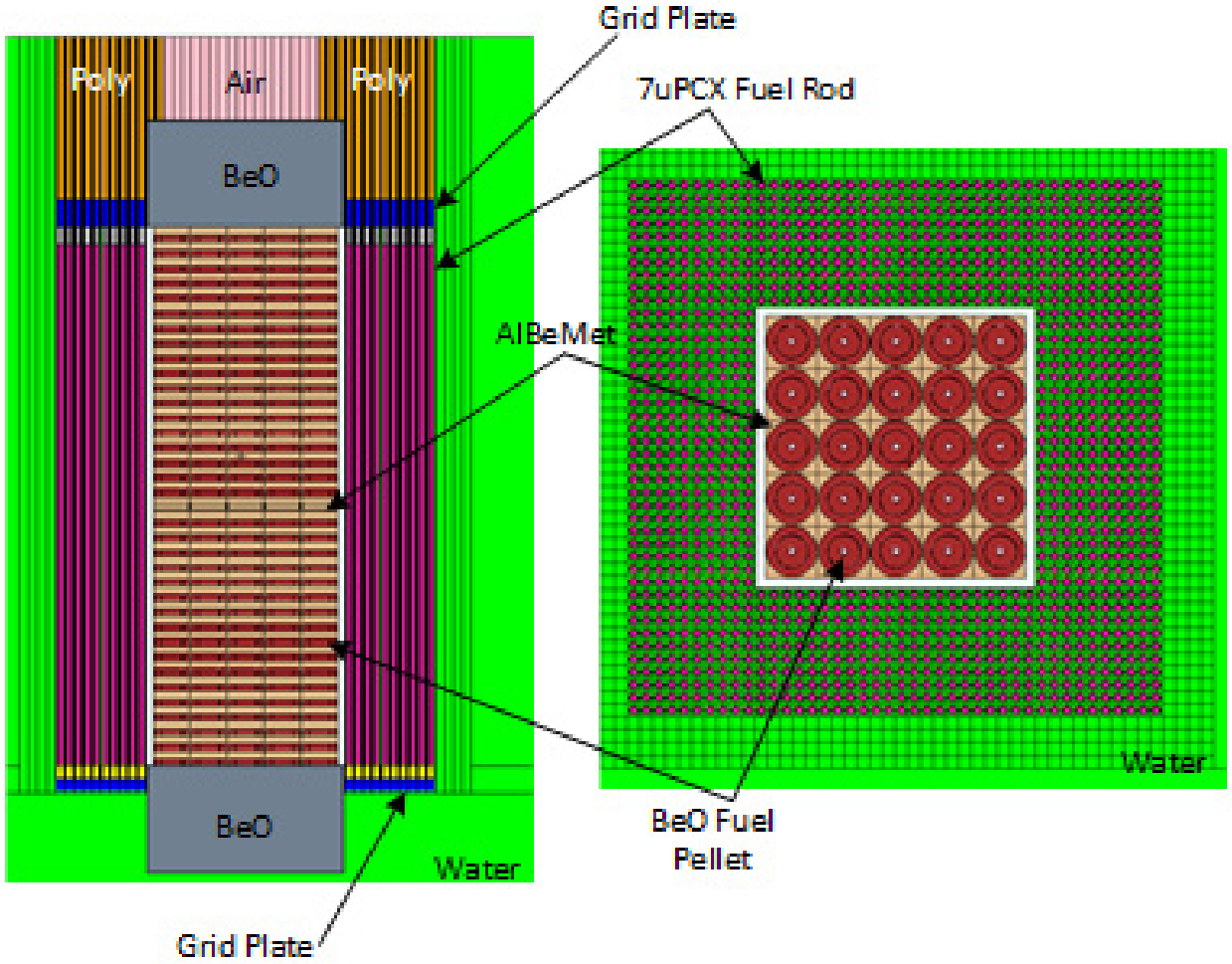
≥ 1289 available

≥ 3795 available

EXPERIMENT DESIGN – UO_2BEO PELLET VARIATIONS

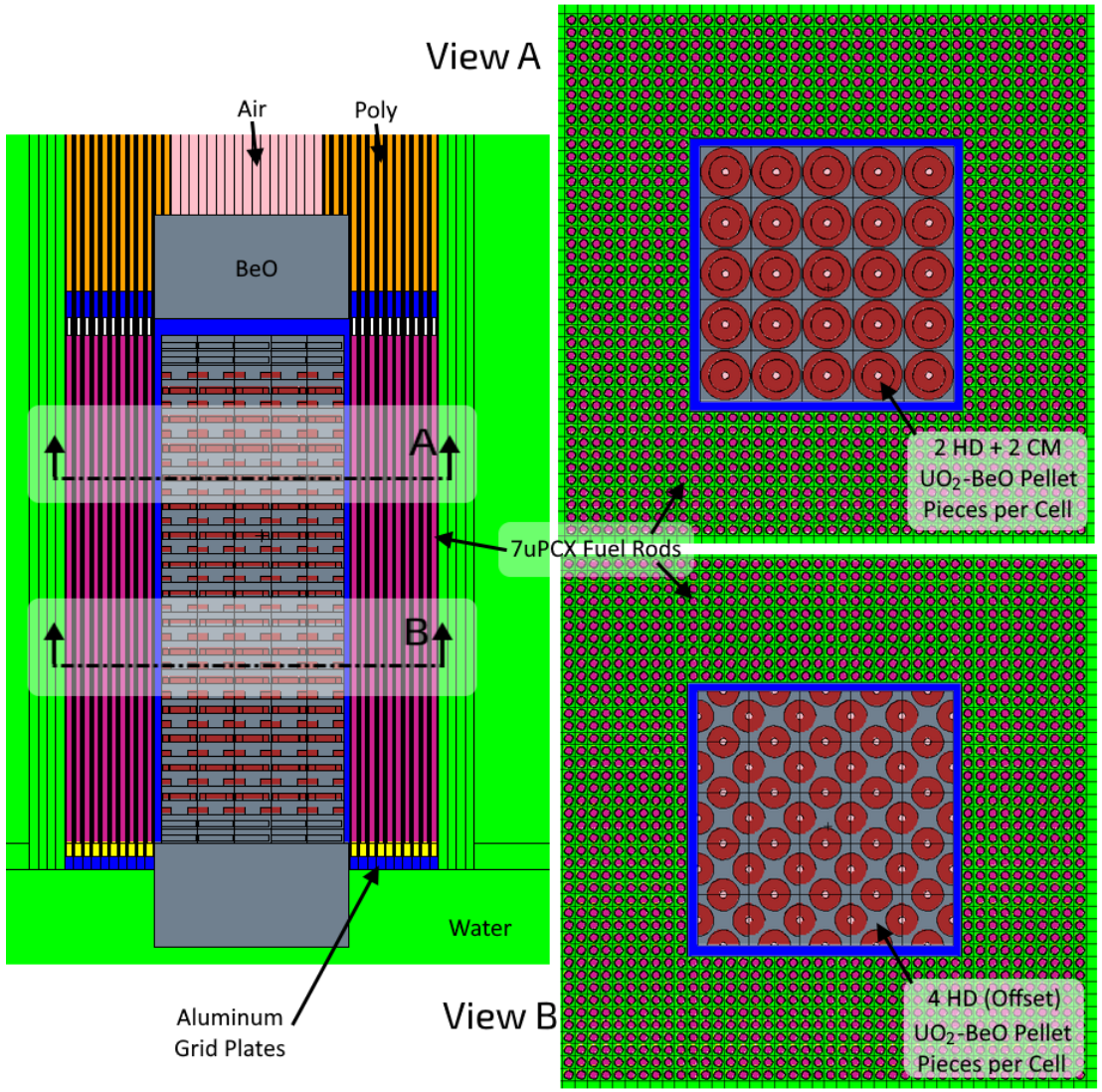


Baseline Pellet Model – Most Similar to CED-0

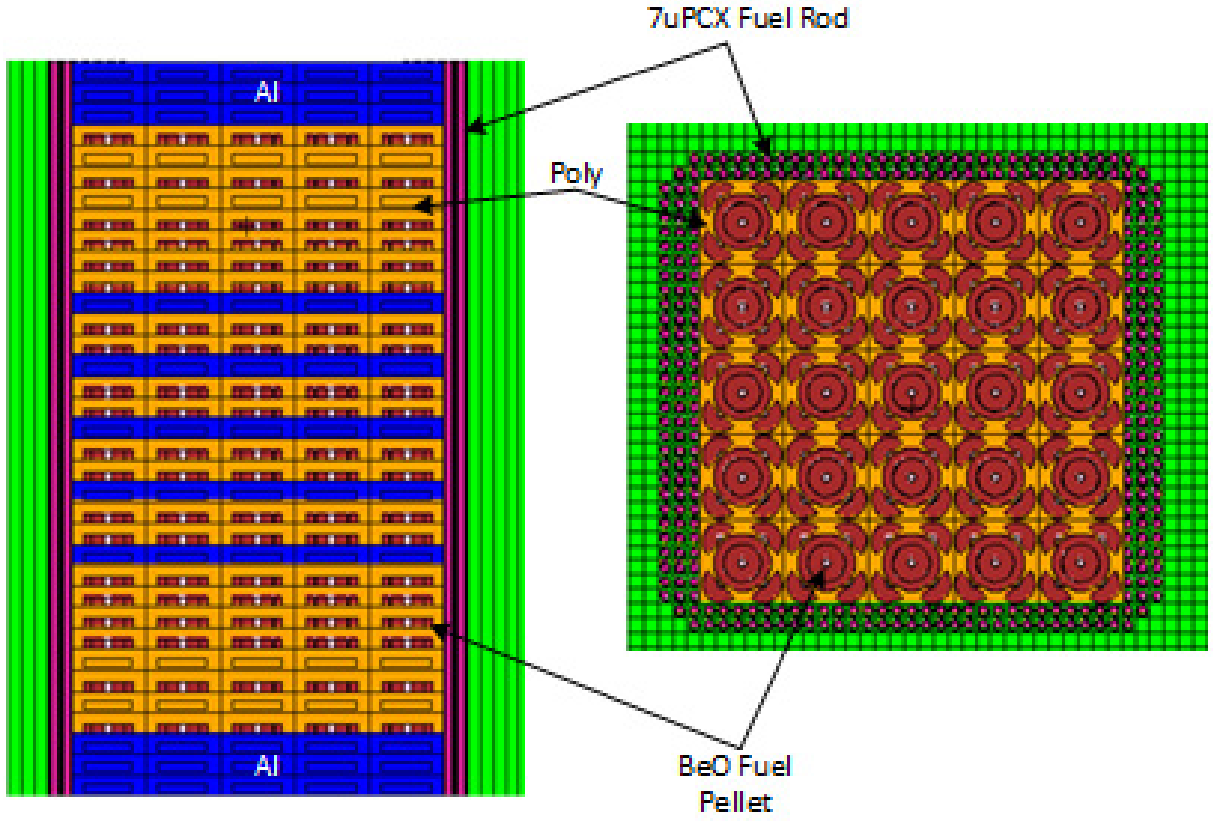


AlBeMet Tray Model

EXPERIMENT DESIGN – UO_2BEO PELLET VARIATIONS



Offset Model

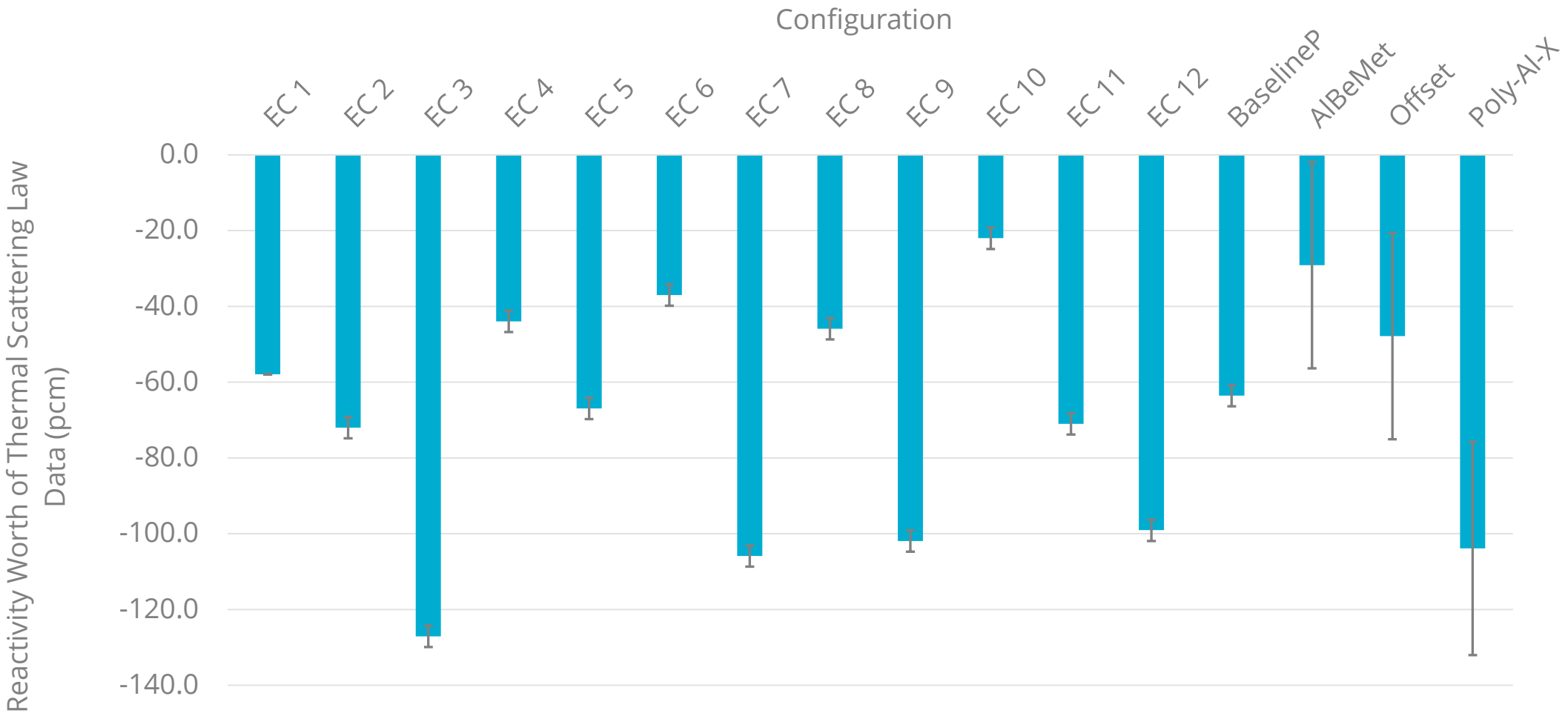


Poly-Al-X Model

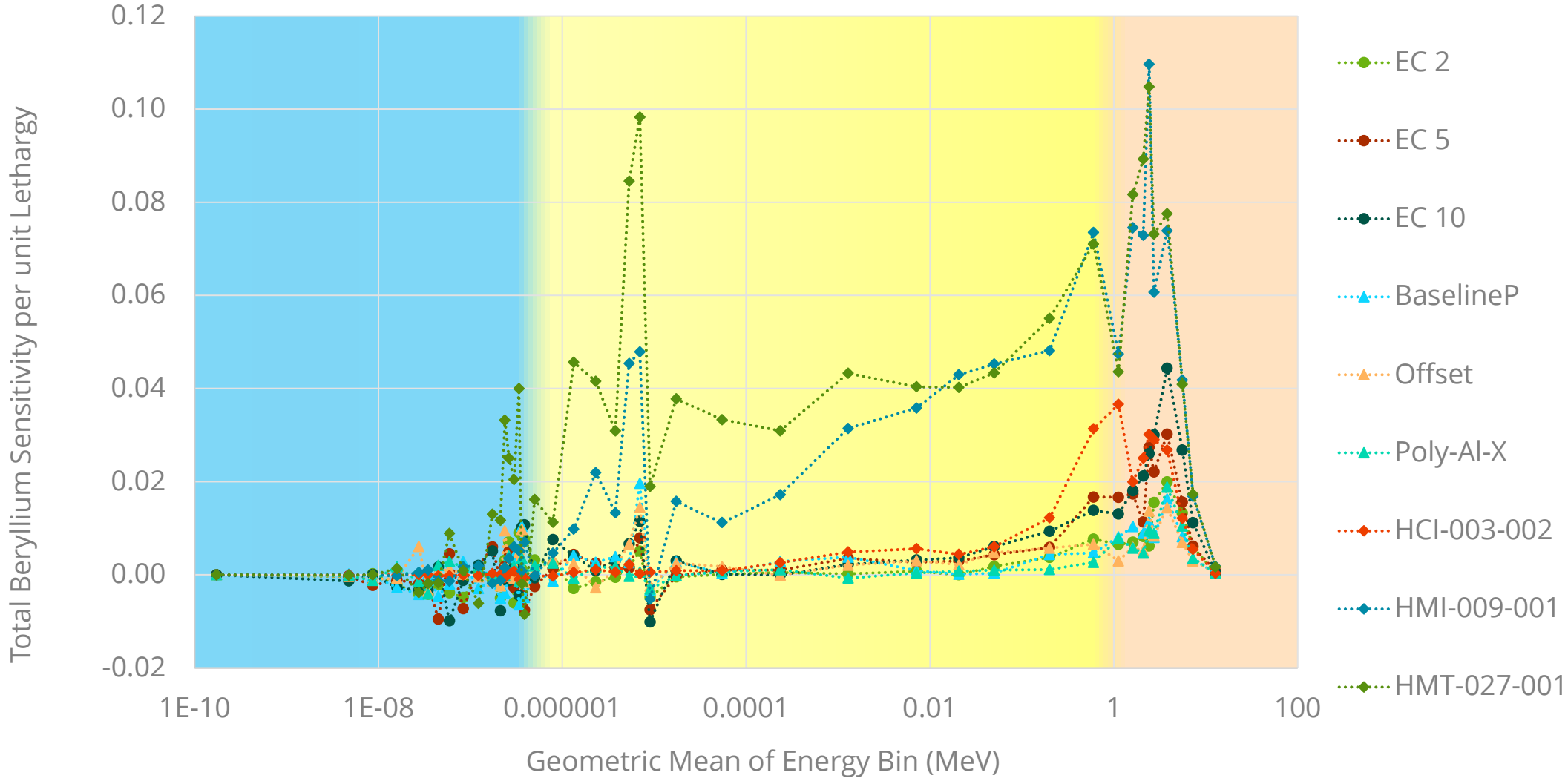
EXPERIMENT DESIGN – PELLET MODELS SUMMARY

Pellet Model	# of 7uPCX Rods	Number of HD/CM	Averaged Enrichment	k_{eff}	3-Group Fission Percentages			k_{eff} without 7uPCX Driver Fuel
					<0.625 eV	0.625 eV-100 keV	>100 keV	
BaselineP	1280	1750/1750	7.60%	1.002	80.10%	15.22%	4.68%	0.510
AlBeMet	1280	1750/1750	7.60%	0.998	80.14%	15.14%	4.72%	0.488
Offset	1280	2350/750	7.47%	1.002	80.33%	14.98%	4.70%	0.496
Poly-Al-X	298	3000/1000	9.80%	1.004	92.59%	5.77%	1.64%	0.891

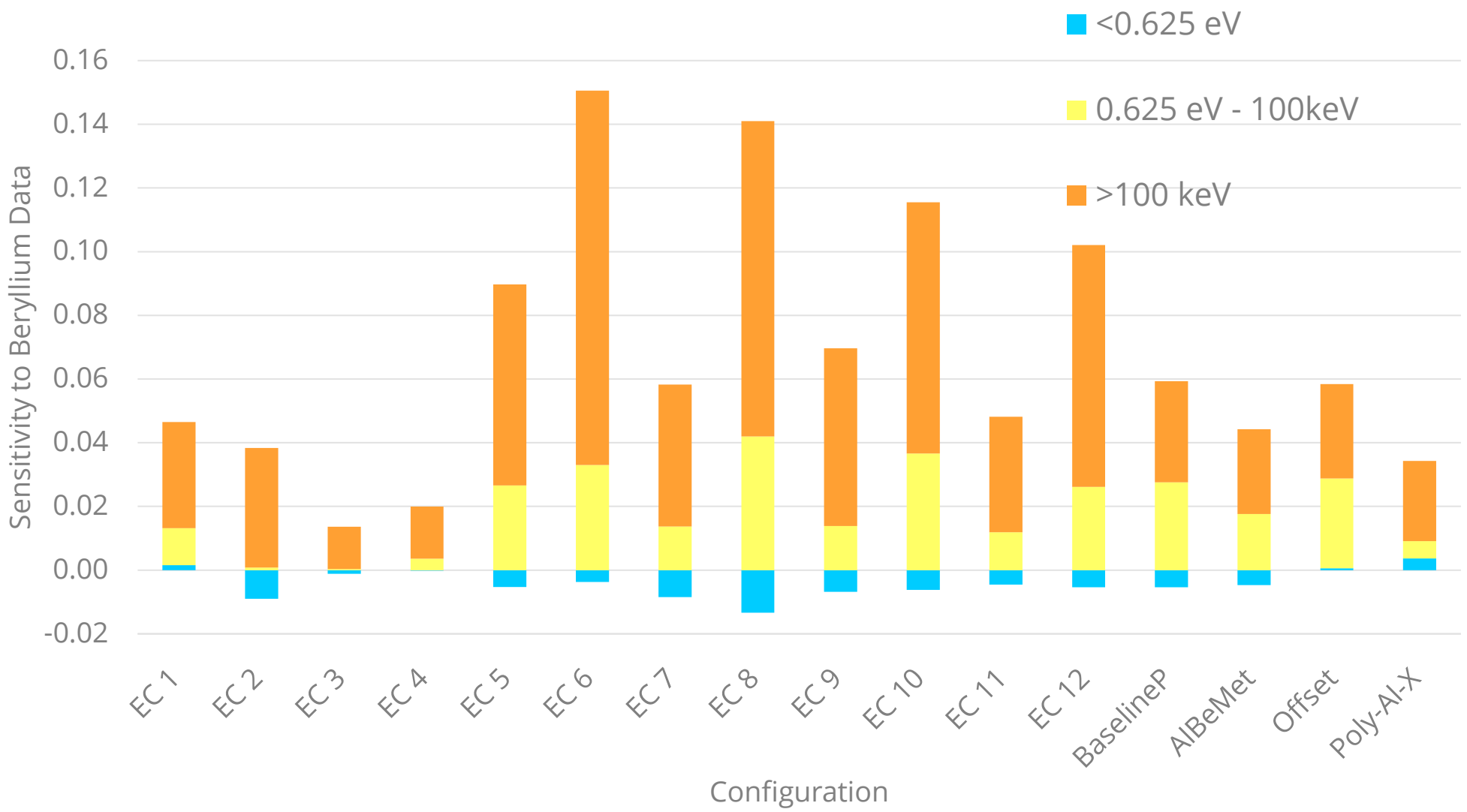
EXAMPLE RESULTS & ANALYSIS – TSL WORTH



EXAMPLE RESULTS & ANALYSIS



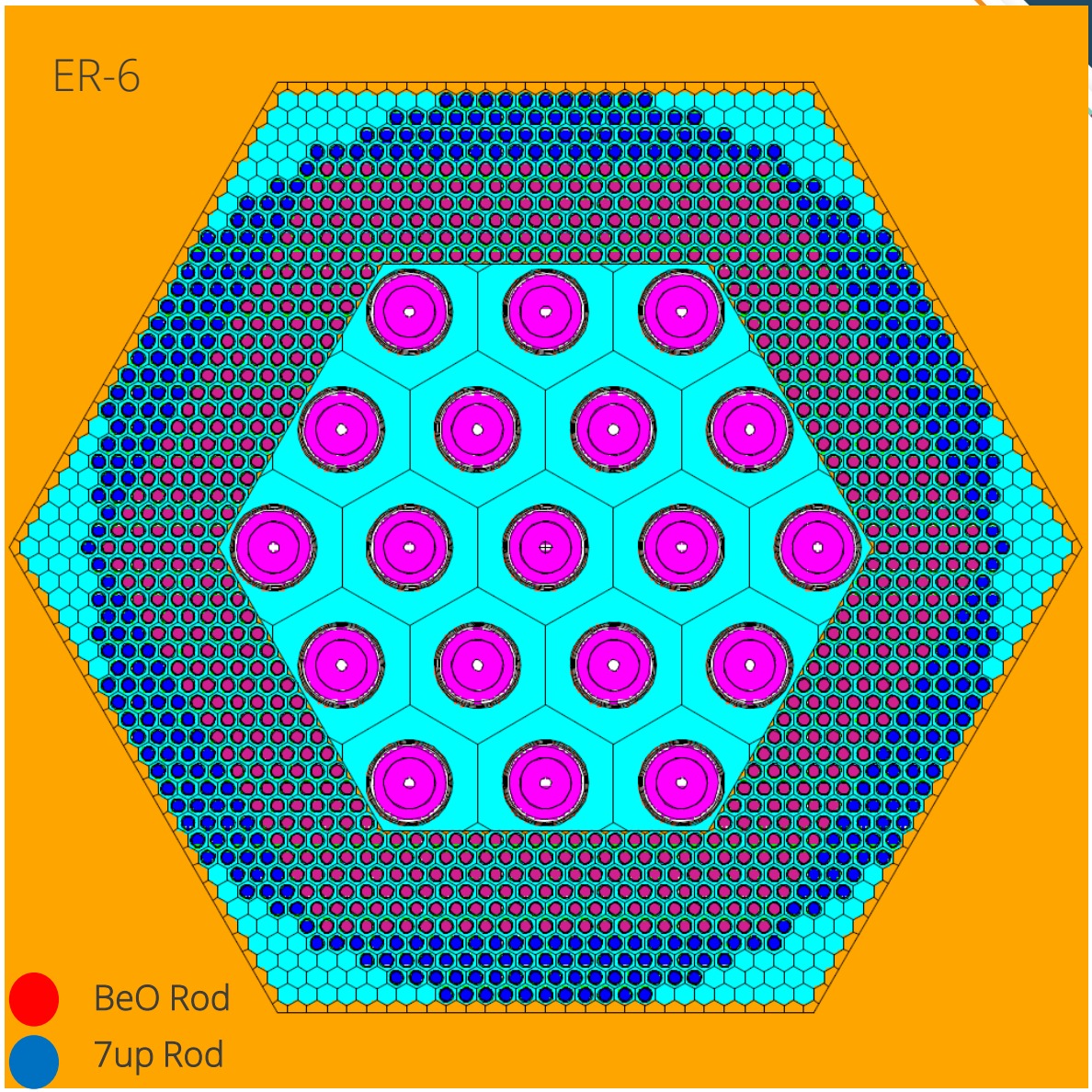
EXAMPLE RESULTS & ANALYSIS



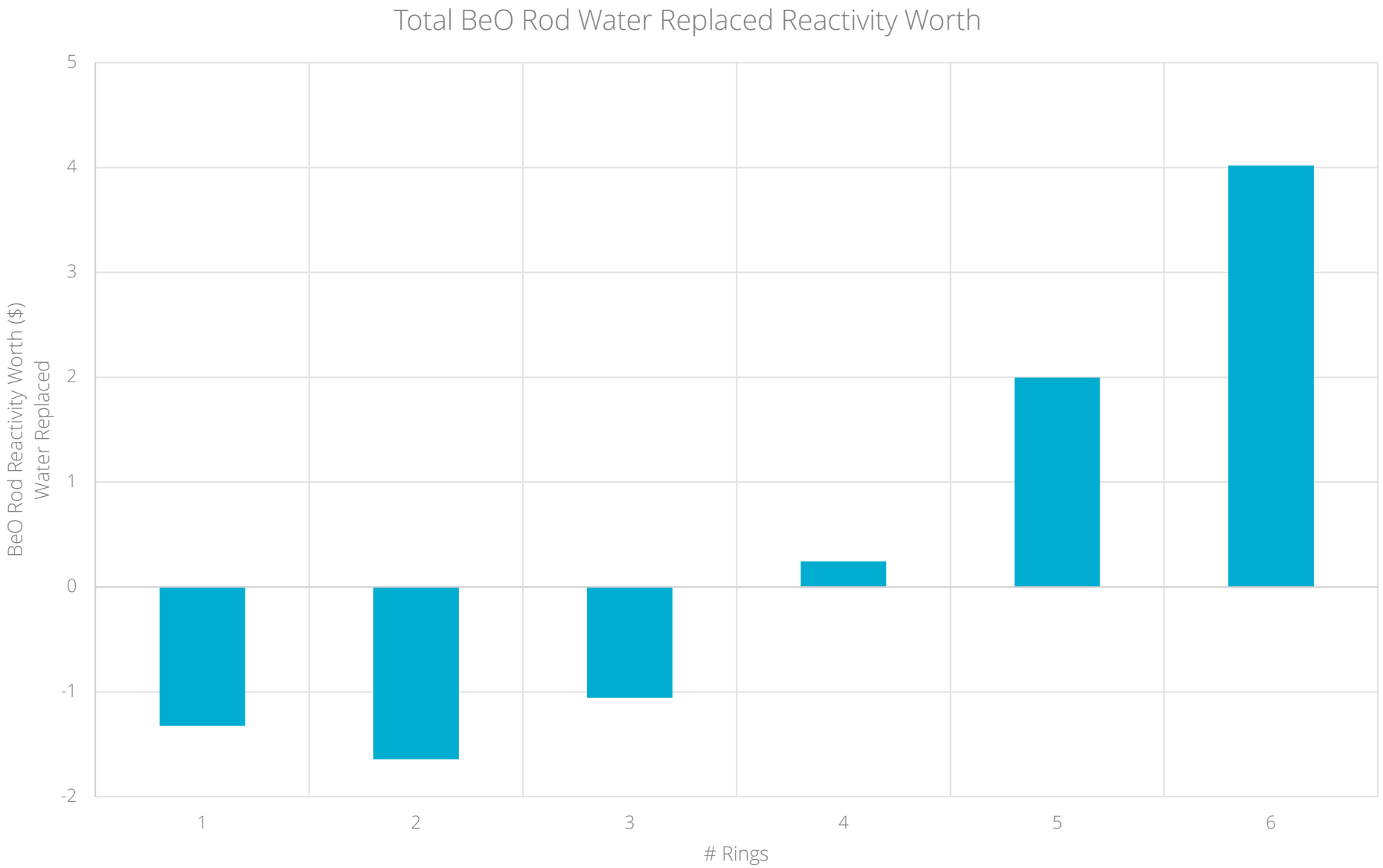
CURRENT EFFORTS

CURRENT EFFORTS

- New Configurations and Arrangements
  - Maximize ACRR rod worth and Be sensitivity
- Consideration of BeO Rod Procurement
  - Impurities, Uncertainties, Cost, Availability
- Analysis of Sample of Available Loose Pellets



CURRENT EFFORTS – DESIGN OPTIMIZATION



CONCLUDING SUMMARY

CONCLUSIONS

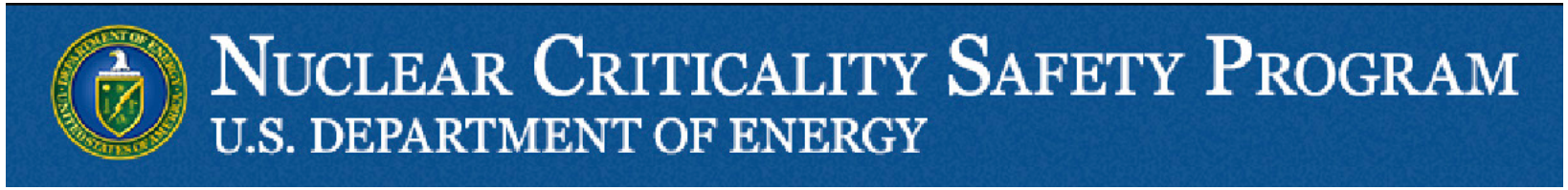
- CED-1 completed in October 2023
  - Similar behavior of fuel element and loose pellet designs
    - Fuel element designs carried into CED-2
- Current efforts focused on optimization
- Future efforts include further design maturation
  - For example, control rod design and analysis

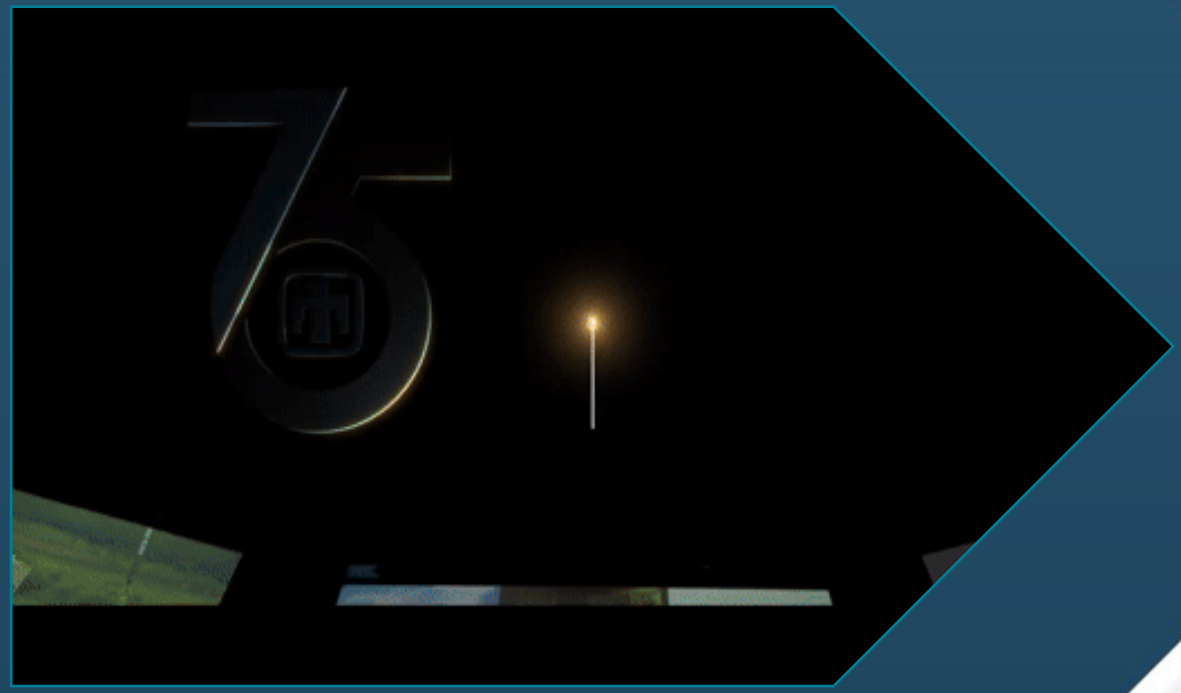
Making History, Shaping the Future

ACKNOWLEDGEMENTS

This work was supported/funded through the DOE-NCSP and NNSA

Thanks to the many contributors of this study





QUESTIONS?

Images Courtesy Sandia National Laboratories