

NCSP IE and T&E Activities at Sandia

Nuclear Criticality Safety Program Technical Program Review

Albuquerque, NM

March 16, 2016

**Presented by
Gary A. Harms
Sandia National Laboratories**

SAND2015-XXXX

Sandia Integral Experiment Requests

IER	Title	Sponsor	CED
206	Re-establish the 4.3% Enriched Critical Experiment Capability at Sandia	SNL	3A
208	7uPCX 0.800 cm Pitch, Variable Depth Pure Water Moderator Experiments	SNL	
209	7uPCX 0.855 cm Pitch, Variable Depth Pure Water Moderator	SNL	2
230	Characterize the Thermal Capabilities of the 7uPCX	SNL	2
285	Titanium Cross Sections in a Thermal Application	SRNL	3B
304	Temperature Dependent Critical Benchmarks	ORNL	0
305	Critical Experiments with UO2 Rods and Molybdenum foils	IRSN	1
306	Critical Experiments with UO2 Rods and Rhodium Foils	IRSN	1

IER-208

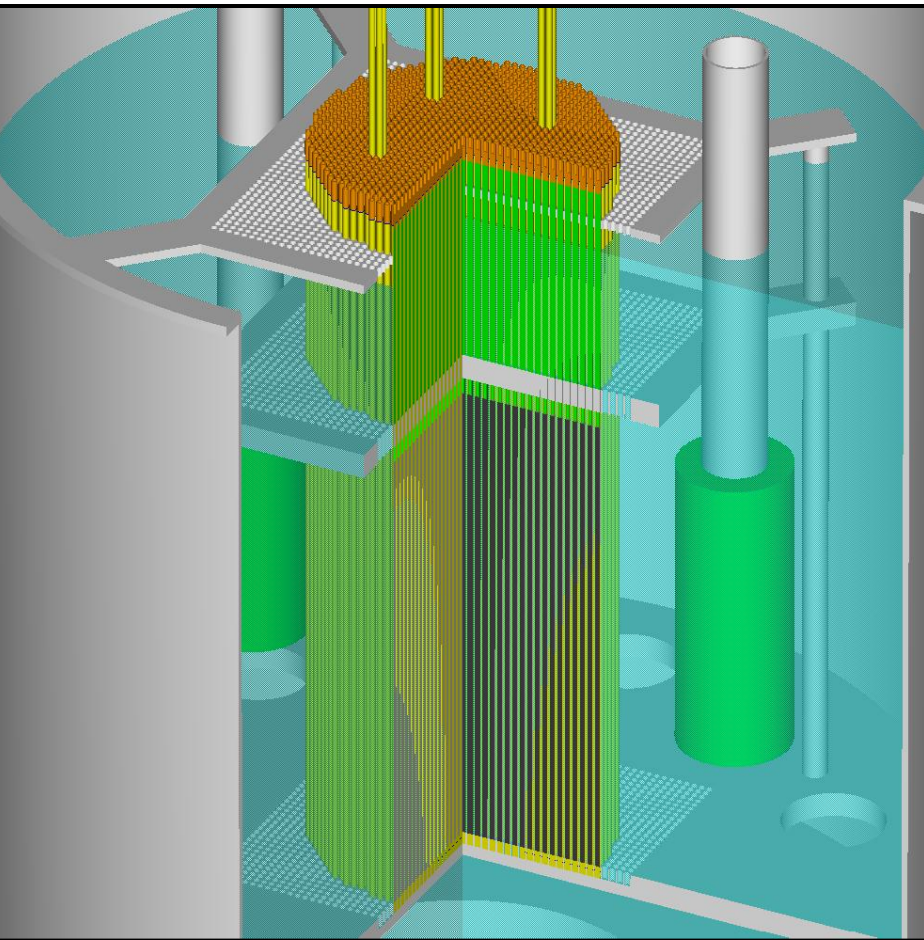
IER	Title	Sponsor	CED
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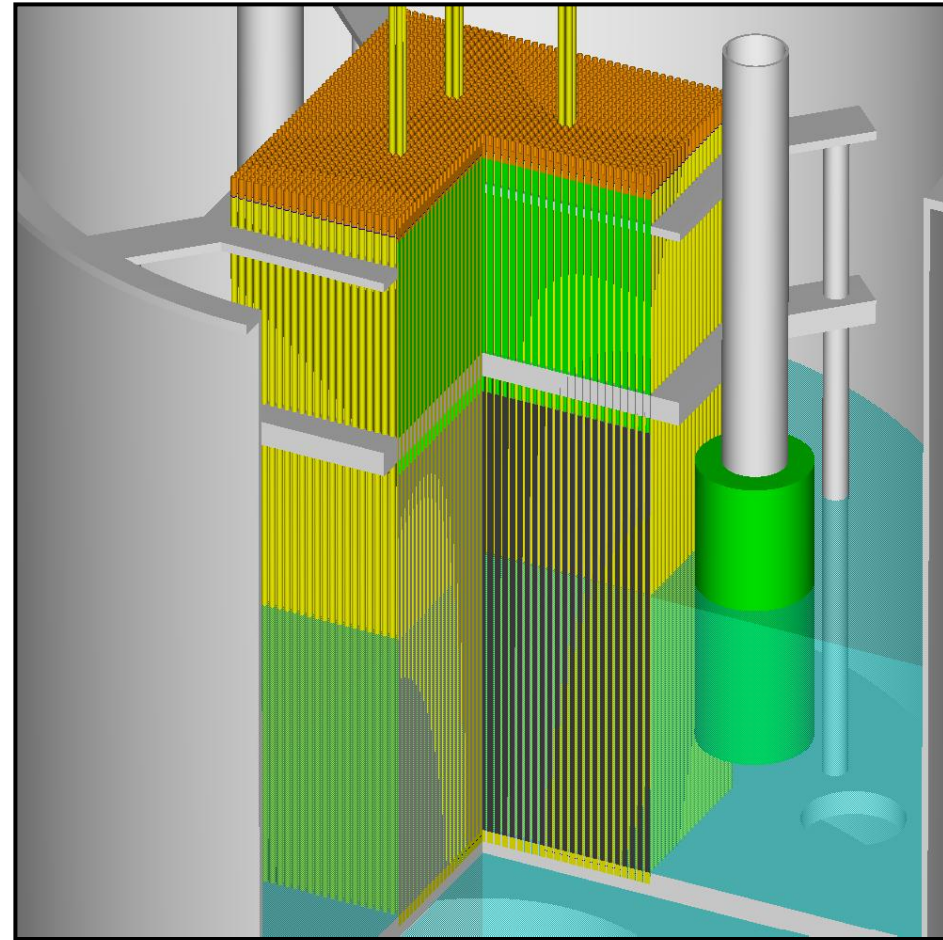
IER-208

- This is our first set of benchmark-quality experiments using the height of the water moderator/reflector in the assembly tank as the approach variable
- Two new hardware systems were installed on the critical assembly
 - The Remotely Adjustable Standpipe (RASP) limits the excess reactivity available during an experiment.
 - Four ultrasonic level sensors to measure the height of the water in the tank
- A benchmark evaluation (LEU-COMP-THERM-096) was completed and is published in the *International Handbook of Evaluated Criticality Safety Benchmark Experiments*

We are now measuring “partially reflected” configurations

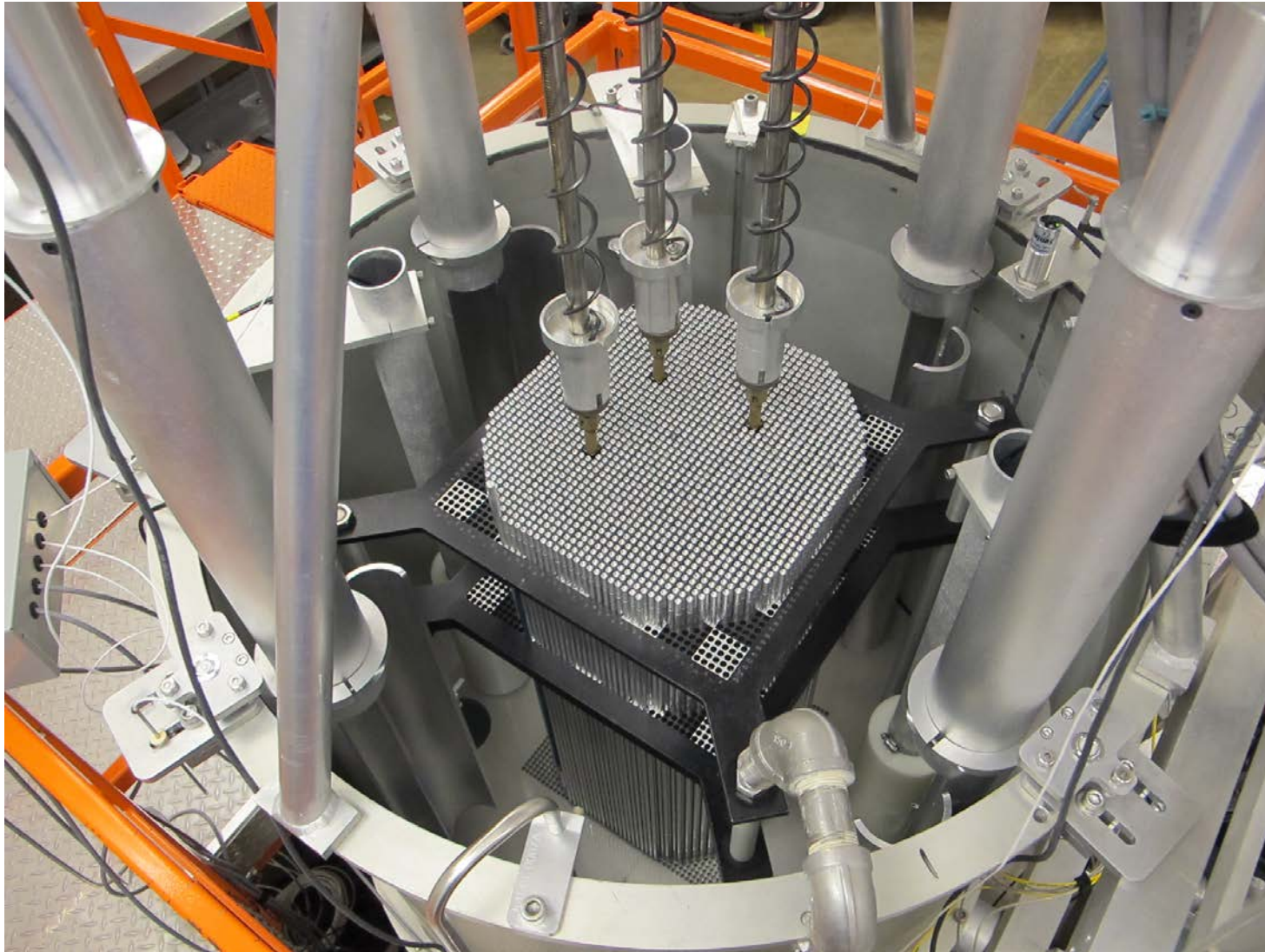


“Fully-Reflected”

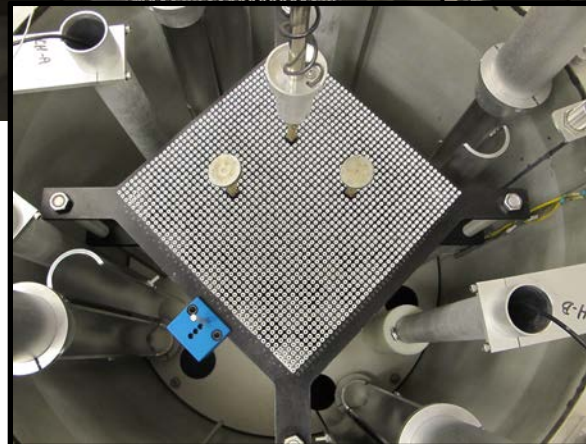
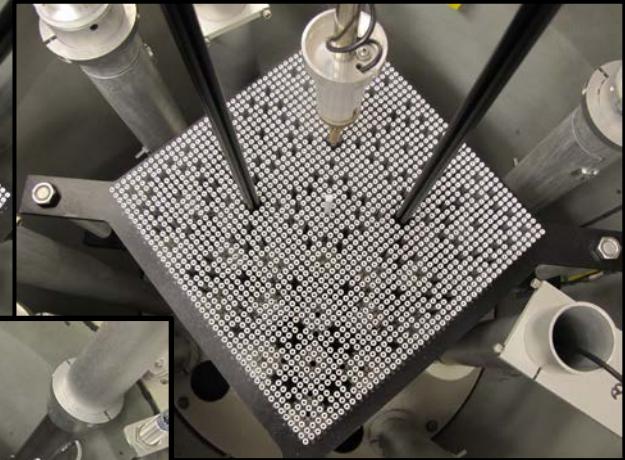
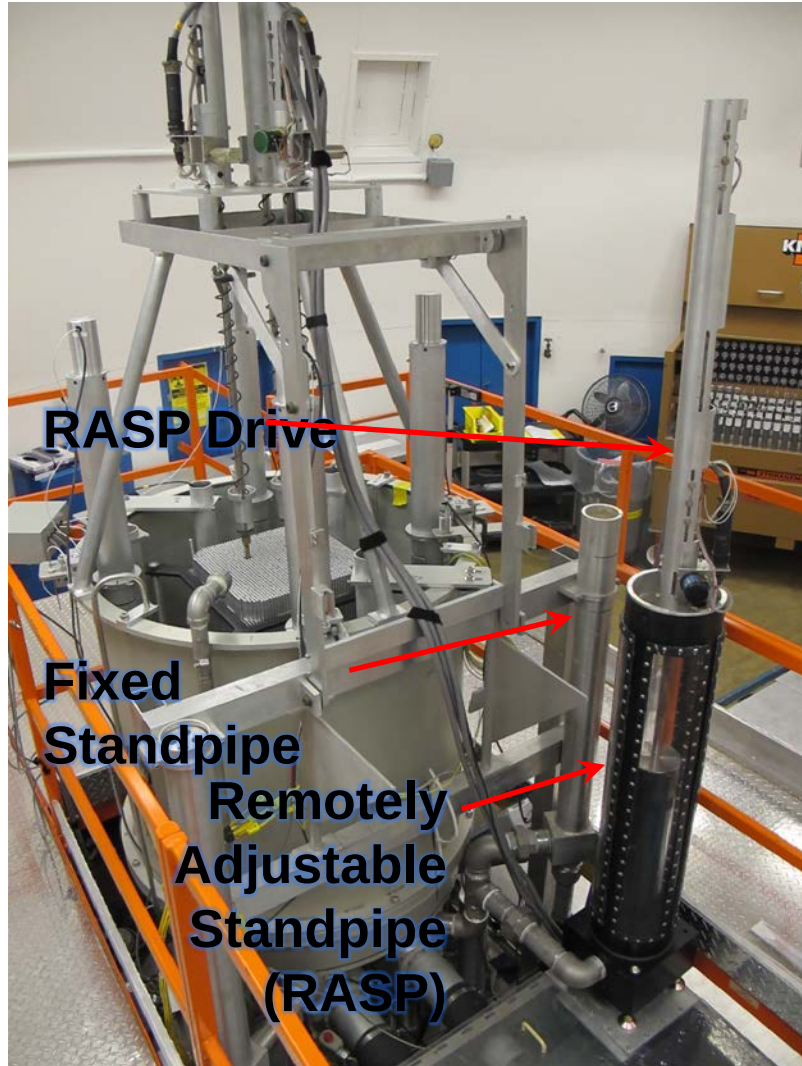


“Partially-Reflected”

IER208



IER208



The bottom line in the LCT096 evaluation

Case	Simplification Bias ^(a)		Temperature Correction Δk_T to Benchmark Model k_{eff} ^(b)		Experiment Uncertainty ^(c)	Bench Model k_{eff}	
	Value	σ	Value	σ		Value ^(d)	σ ^(e)
1	-0.00016	0.00003	0.00001	0.00000	0.00095	0.99985	0.00095
2	-0.00007	0.00003	0.00001	0.00000	0.00095	0.99994	0.00095
3	-0.00013	0.00003	0.00001	0.00000	0.00093	0.99988	0.00093
4	-0.00016	0.00003	0.00001	0.00000	0.00095	0.99985	0.00095
5	-0.00014	0.00003	0.00001	0.00000	0.00095	0.99987	0.00095
6	-0.00019	0.00003	0.00000	0.00000	0.00092	0.99981	0.00092
7	-0.00014	0.00003	0.00000	0.00000	0.00092	0.99986	0.00092
8	-0.00013	0.00003	0.00000	0.00000	0.00092	0.99987	0.00092
9	-0.00006	0.00003	0.00000	0.00000	0.00092	0.99994	0.00092
10	-0.00012	0.00003	0.00000	0.00000	0.00092	0.99988	0.00092
11	-0.00002	0.00003	-0.00001	0.00000	0.00095	0.99997	0.00096
12	0.00000	0.00003	0.00000	0.00000	0.00095	1.00000	0.00096
13	-0.00010	0.00003	0.00000	0.00000	0.00095	0.99990	0.00096
14	-0.00008	0.00003	0.00001	0.00000	0.00095	0.99993	0.00096
15	-0.00011	0.00003	0.00002	0.00000	0.00095	0.99991	0.00096
16	-0.00006	0.00003	-0.00001	0.00000	0.00095	0.99993	0.00096
17	-0.00008	0.00003	-0.00001	0.00000	0.00095	0.99991	0.00096
18	-0.00006	0.00003	0.00000	0.00000	0.00095	0.99994	0.00096
19	-0.00013	0.00003	0.00000	0.00000	0.00095	0.99987	0.00096

IER-285

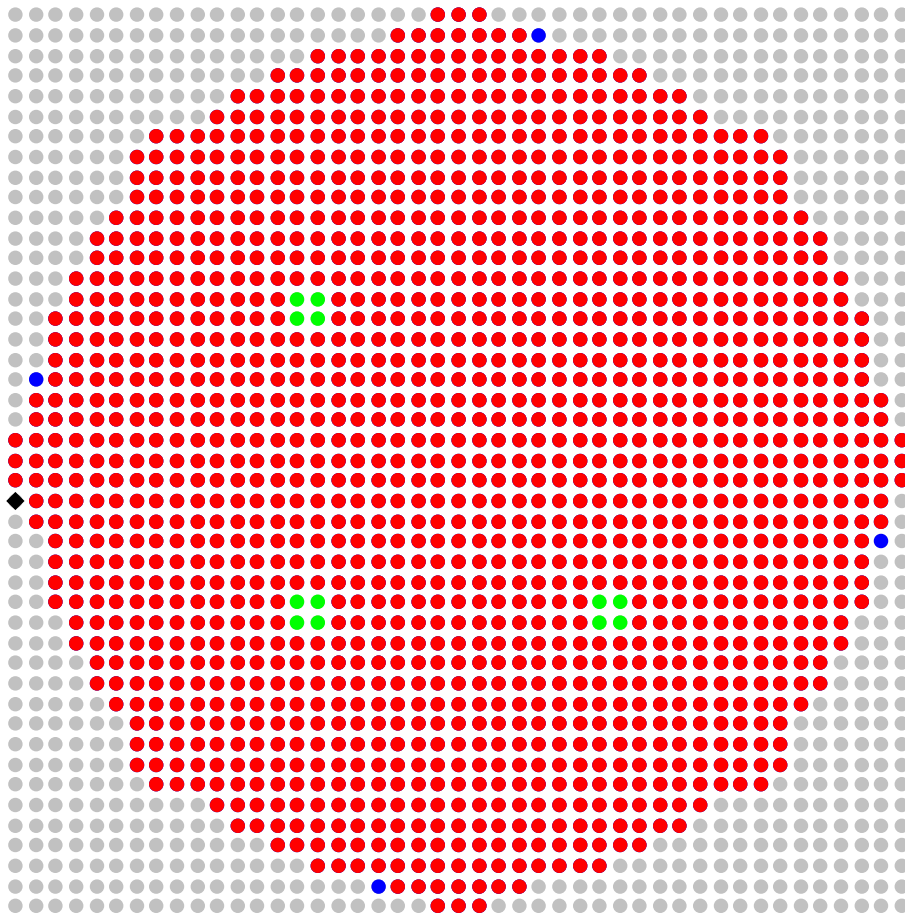
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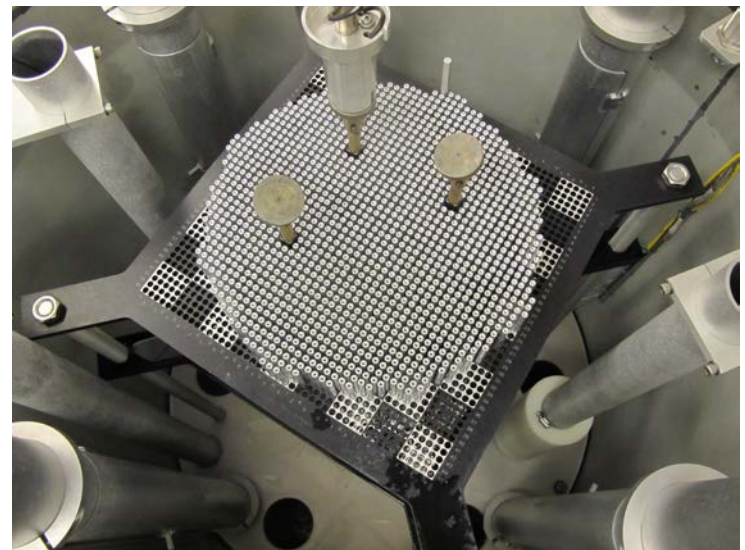
IER-285

- This experiment was done to answer a request from SRNL for integral critical experiments with titanium in a thermal system
- This experiment series was done as a set of progressive fuel-rod-replacement experiments in the 7uPCX critical assembly
- We used titanium and aluminum replacement rods
- A benchmark evaluation (LEU-COMP-THERM-097) is being prepared for publication in the *International Handbook of Evaluated Criticality Safety Benchmark Experiments*
- We are working on a set of experiments with titanium sleeves on another set of fuel rods (BUCCX)

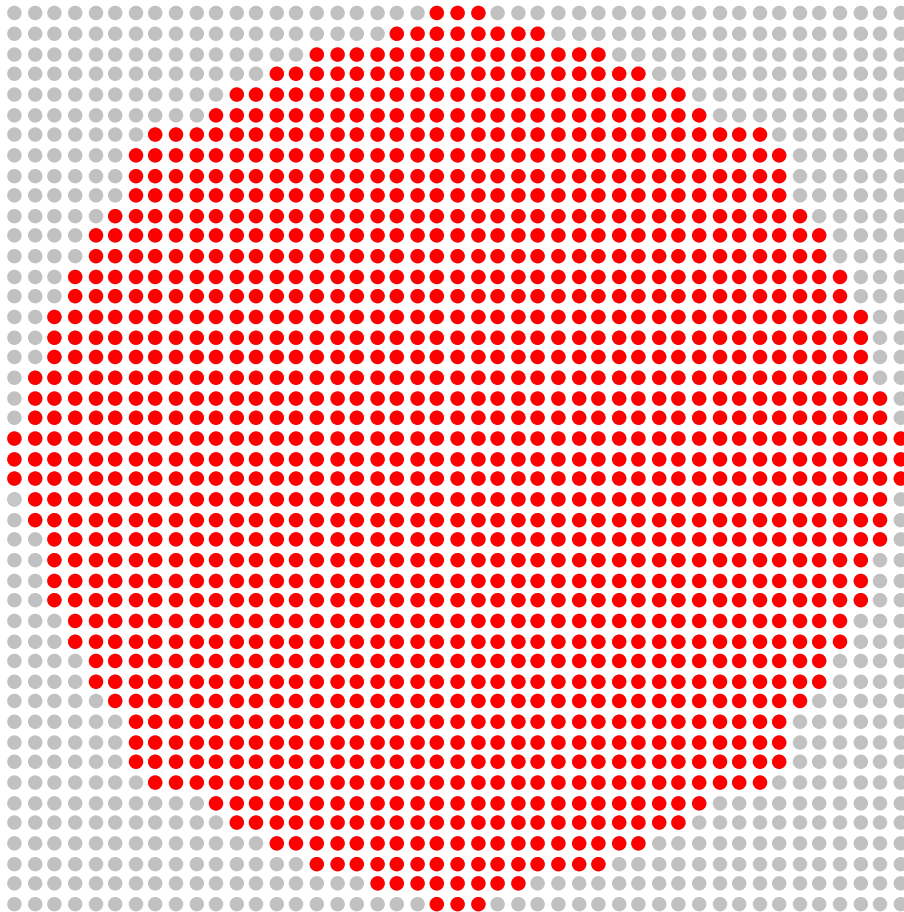
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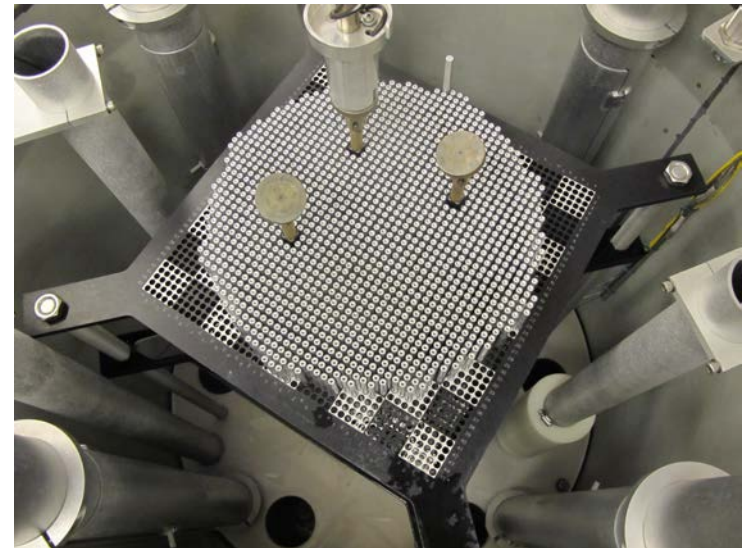
- Fuel Rod
- Incremental Fuel Rod
- ◆ Control/Safety Rod
- Empty Grid Location
- ◆ Source Location



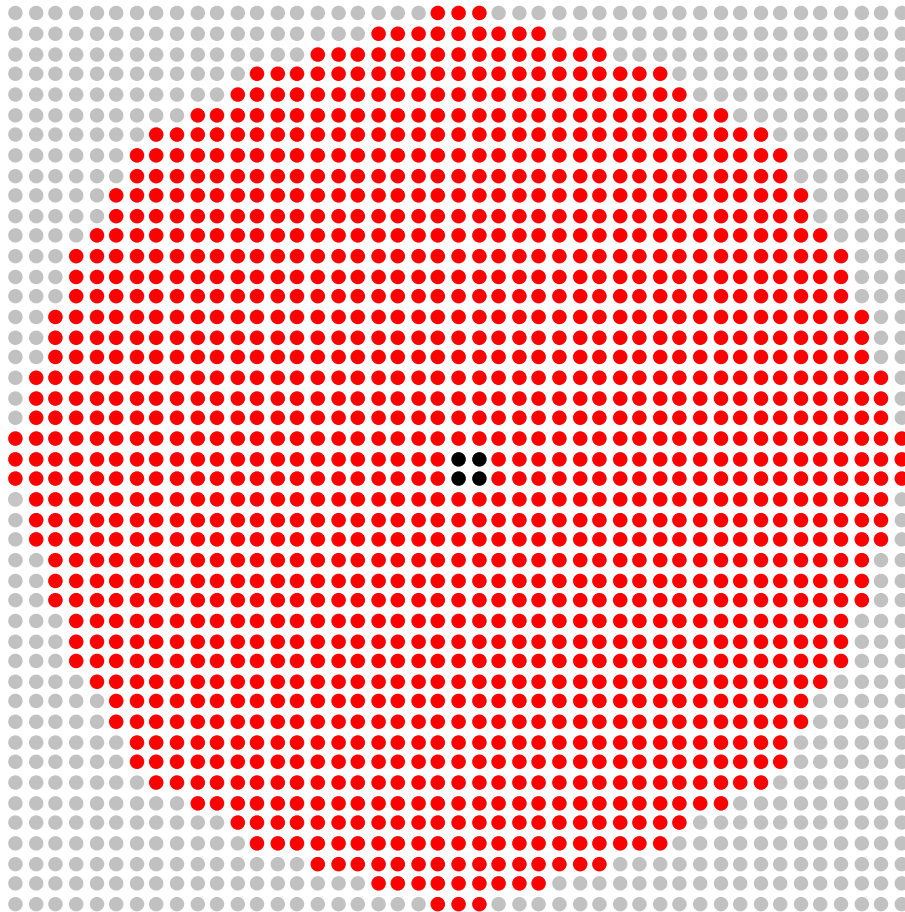
Case 1



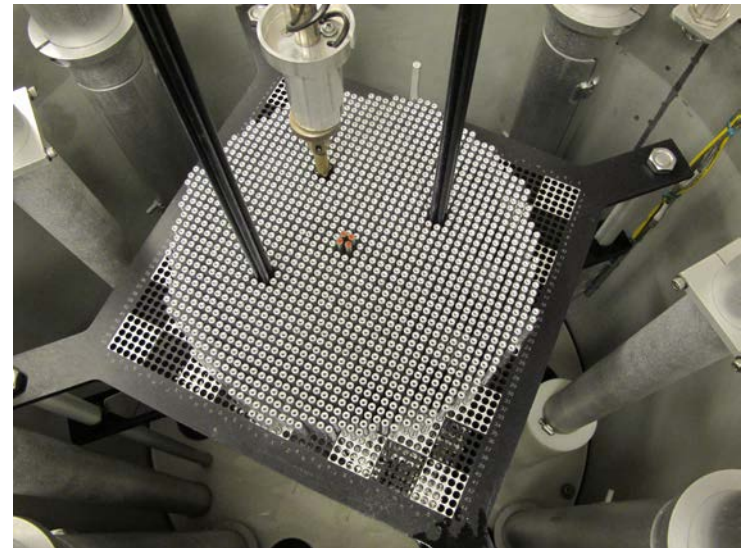
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- Empty Grid Location



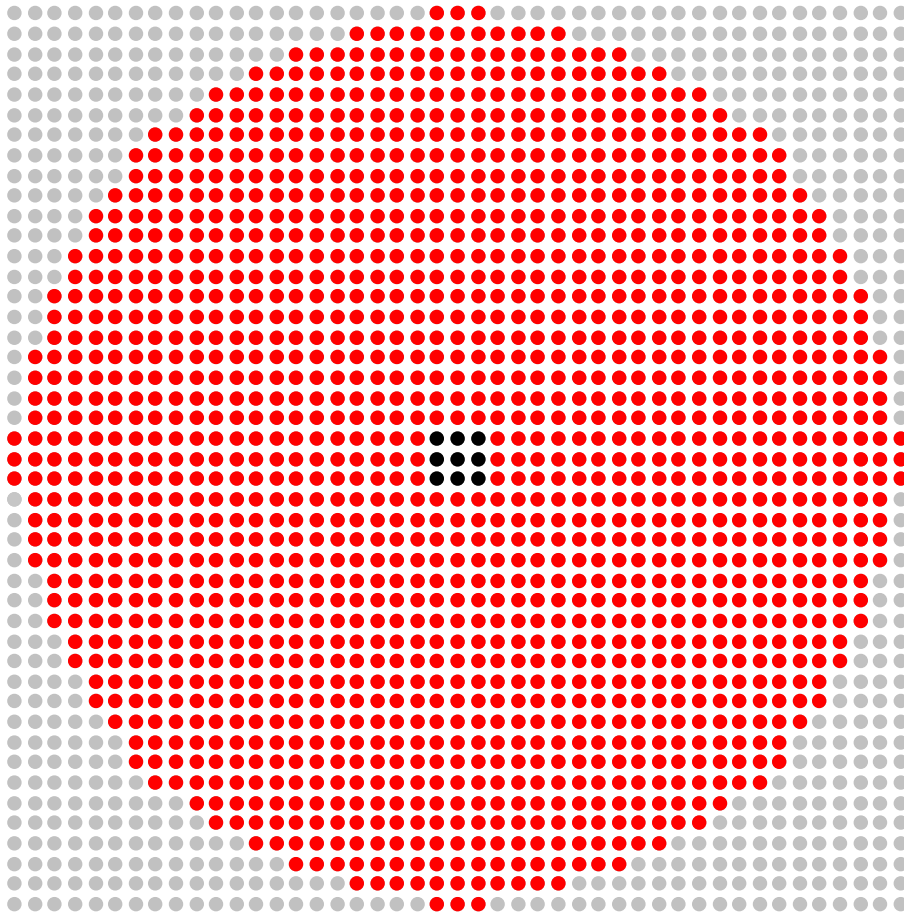
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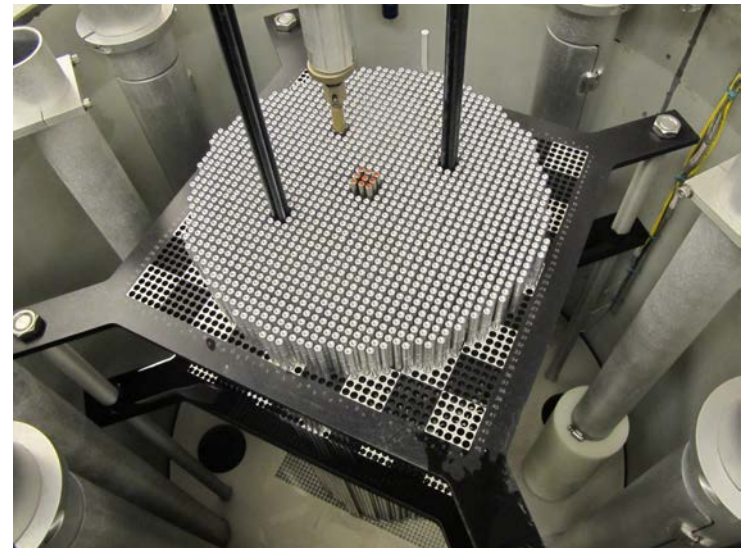
- Fuel Rod
- Empty Grid Location
- Titanium Experiment Rod



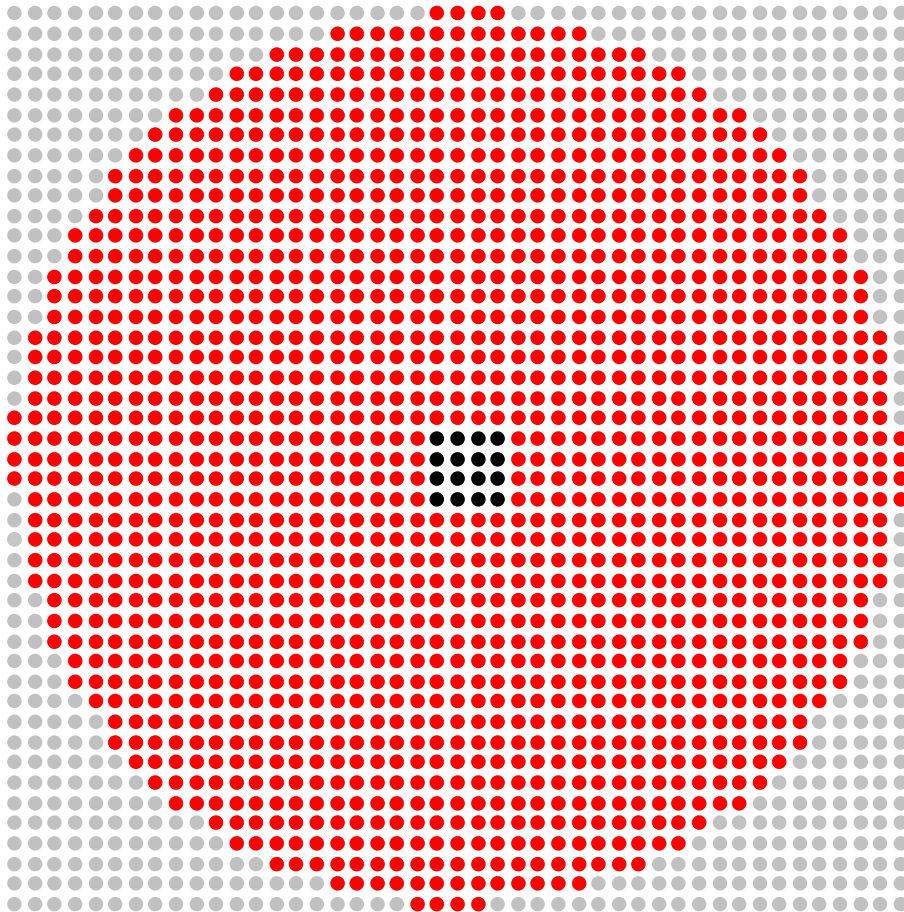
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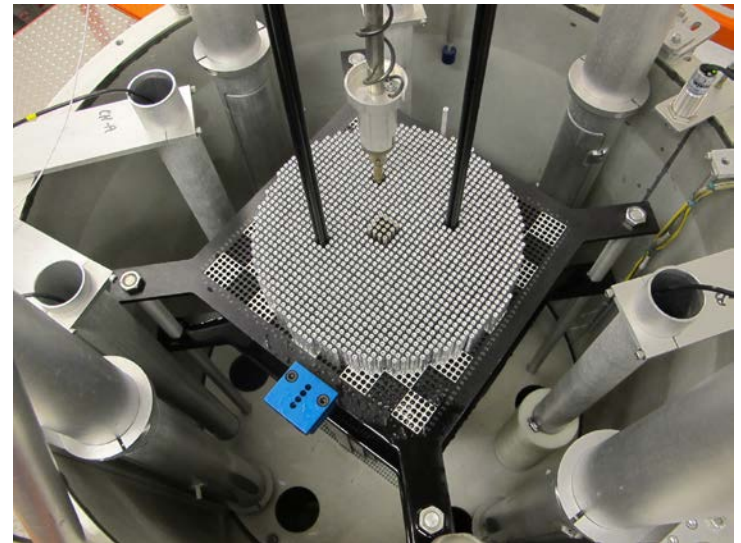
- Fuel Rod
- Empty Grid Location
- Titanium Experiment Rod



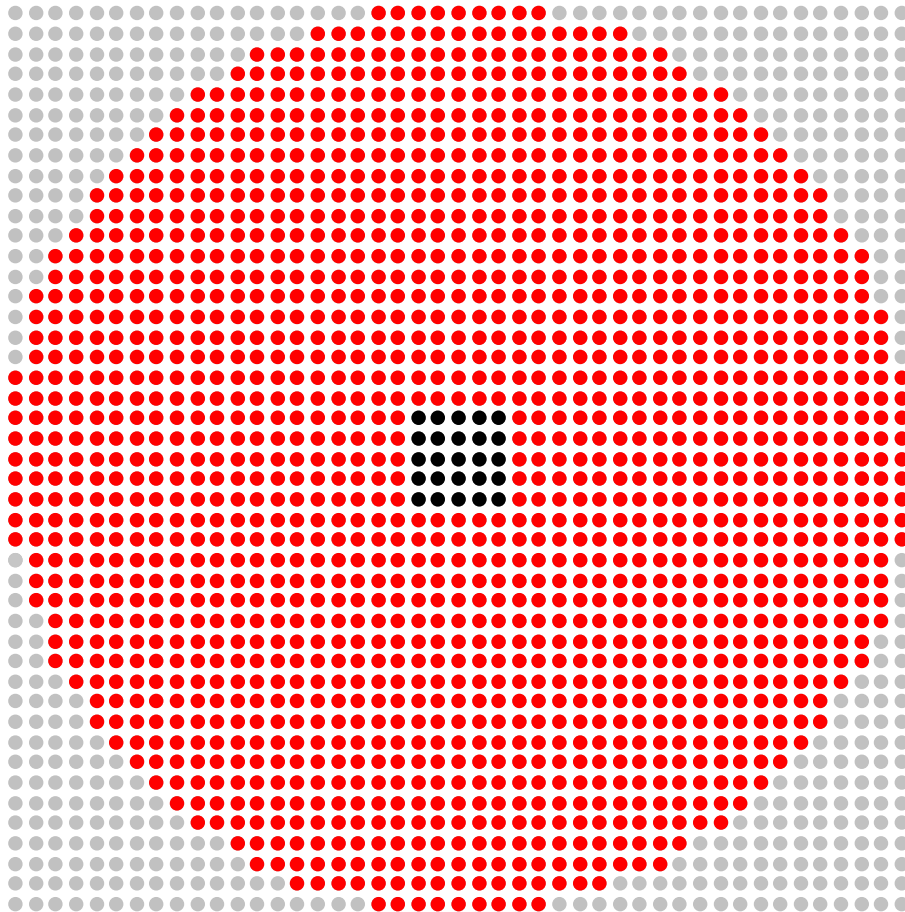
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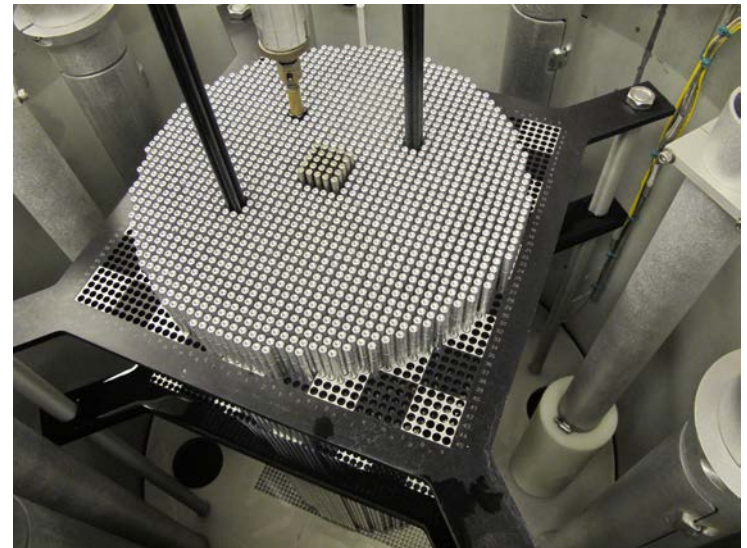
- Fuel Rod
- Empty Grid Location
- Titanium Experiment Rod



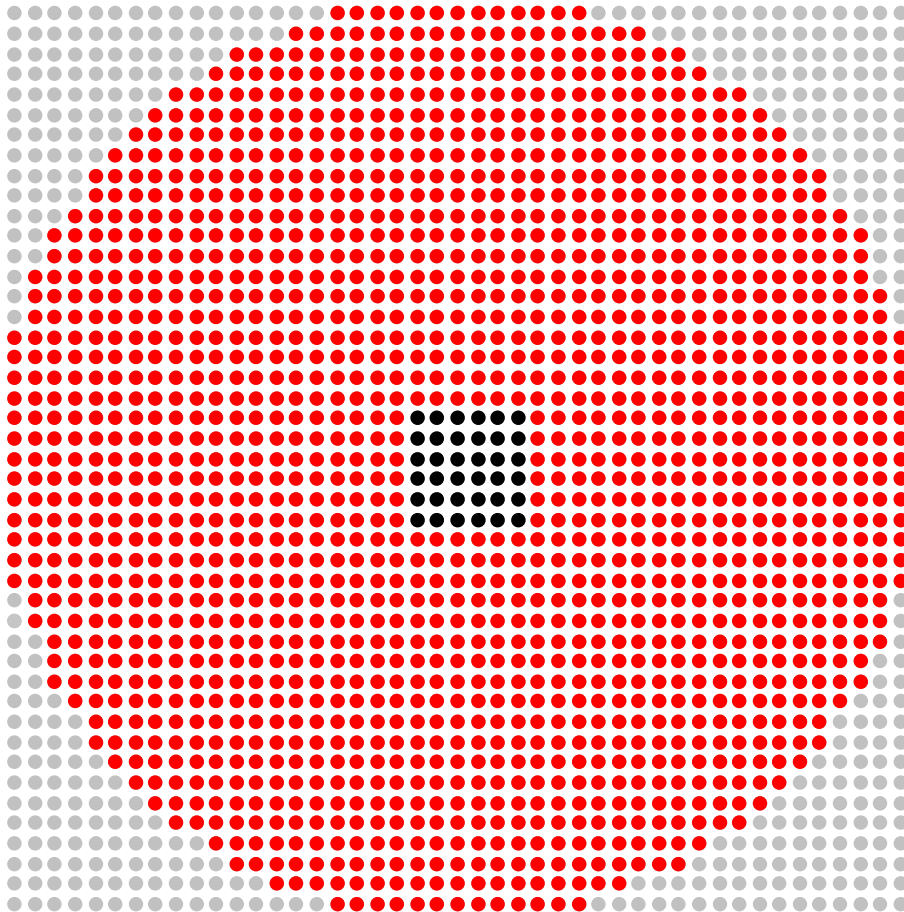
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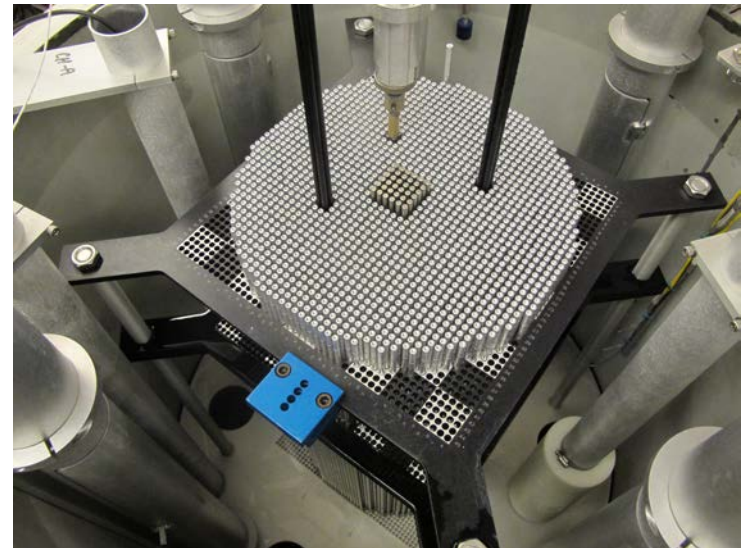
- Fuel Rod
- Empty Grid Location
- Titanium Experiment Rod



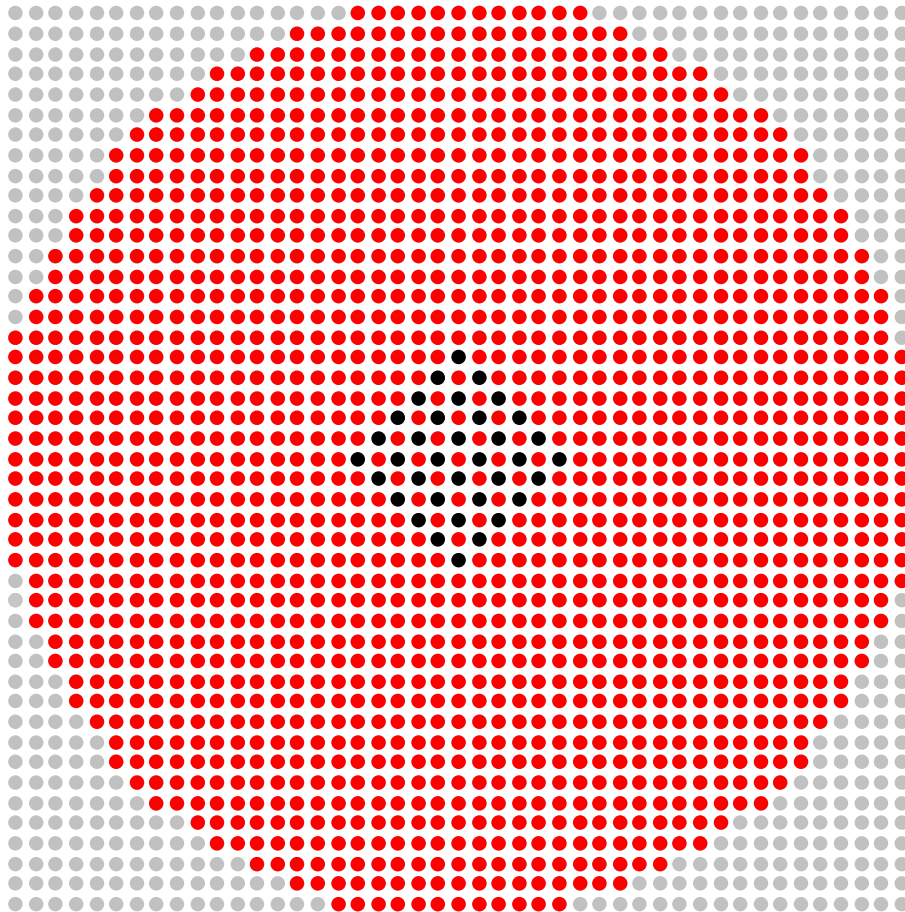
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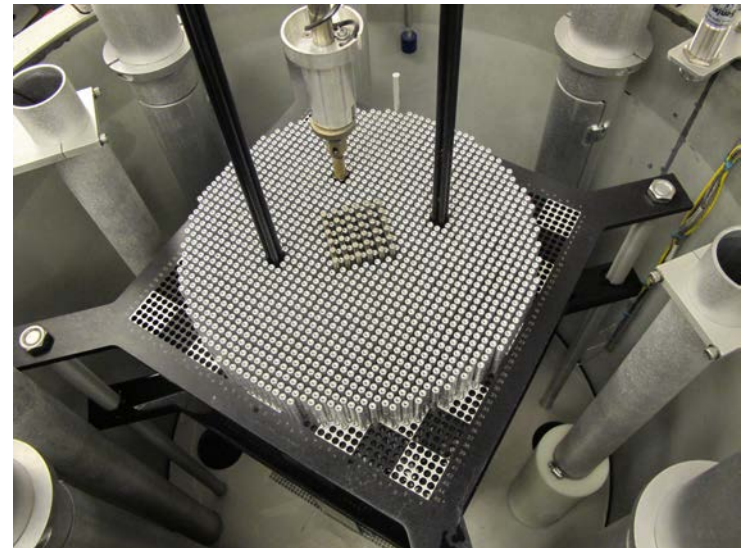
- Fuel Rod
- Empty Grid Location
- Titanium Experiment Rod



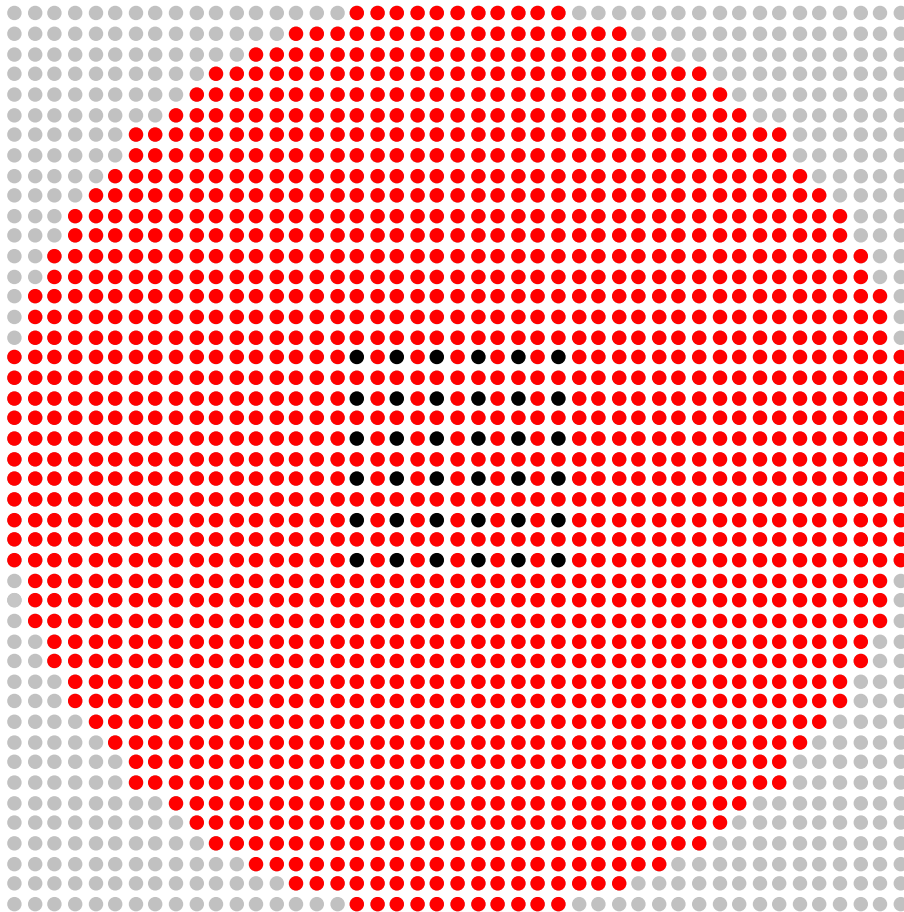
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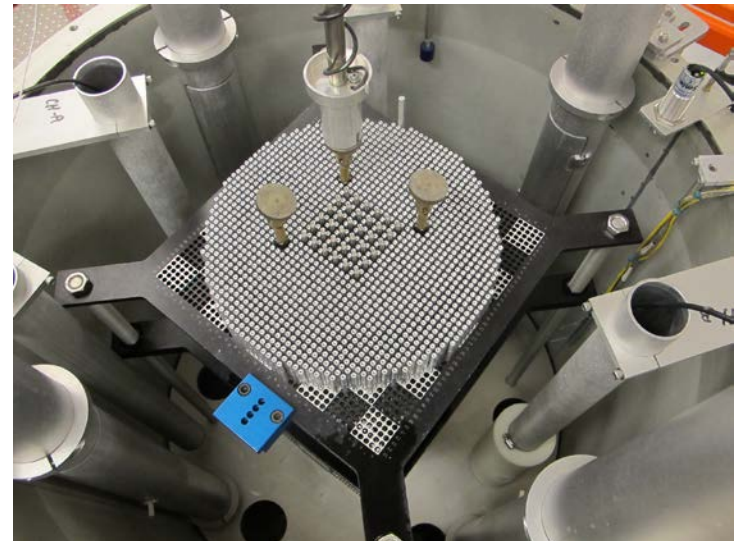
- Fuel Rod
- Empty Grid Location
- Titanium Experiment Rod



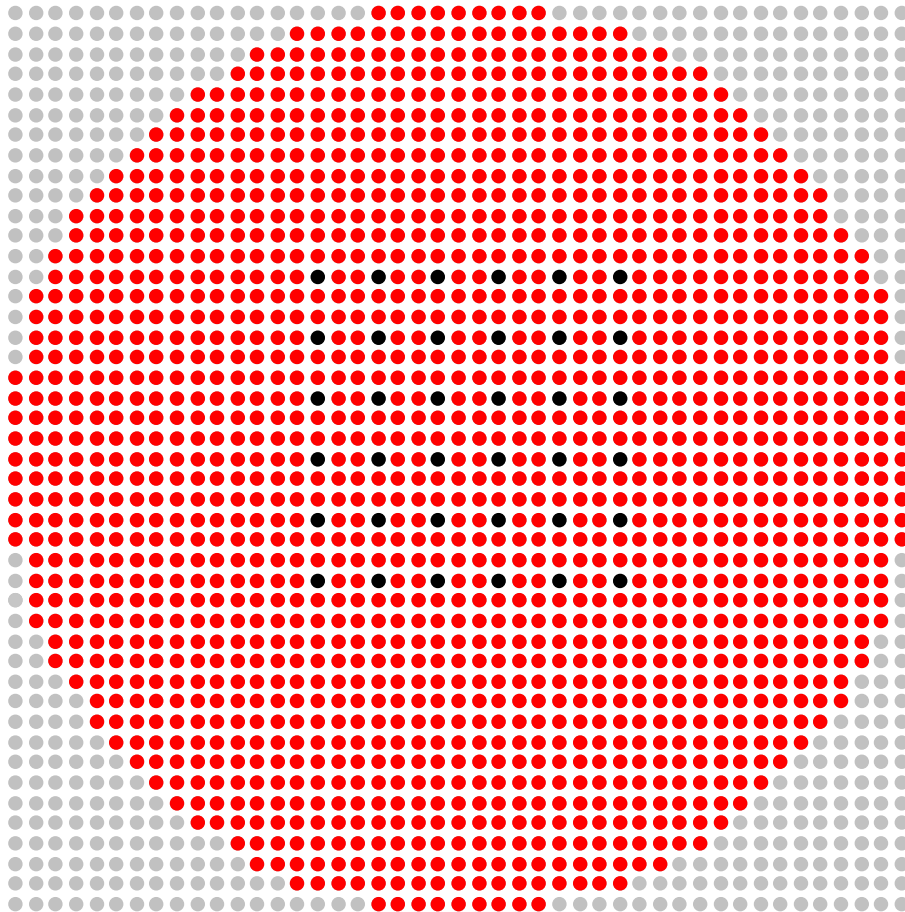
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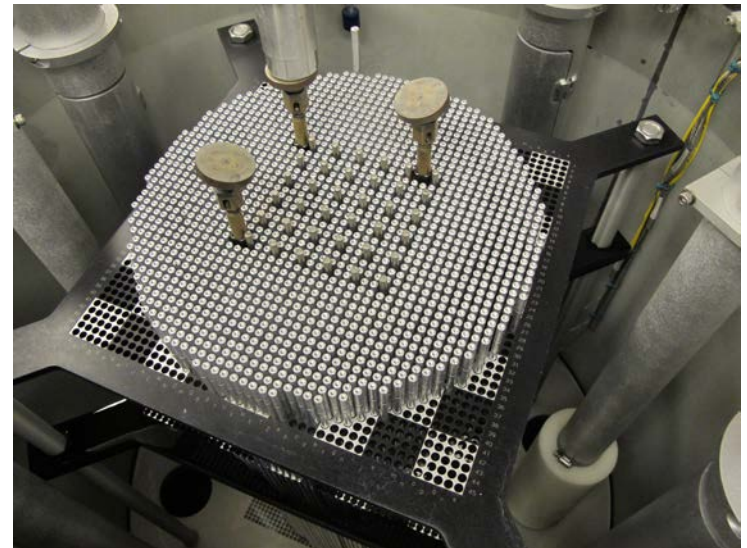
- Fuel Rod
- Empty Grid Location
- Titanium Experiment Rod



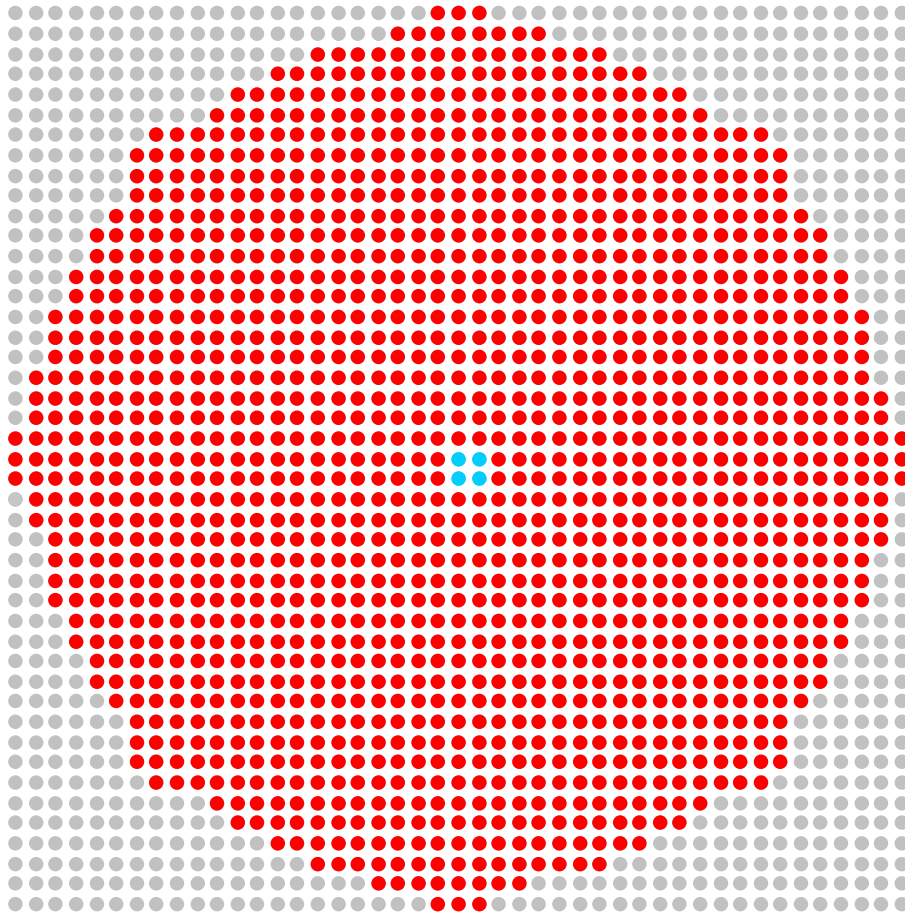
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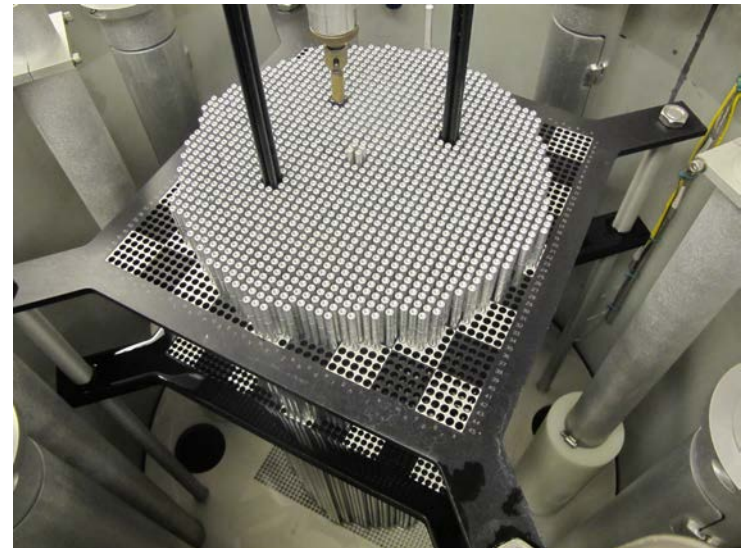
- Fuel Rod
- Empty Grid Location
- Titanium Experiment Rod



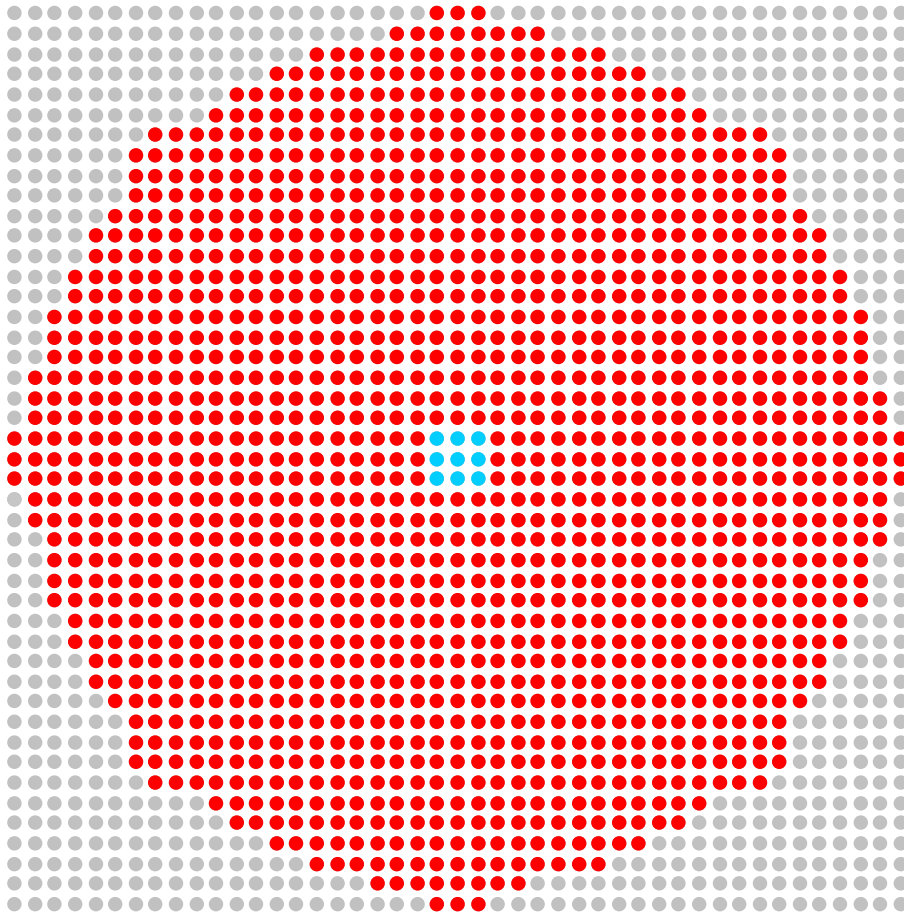
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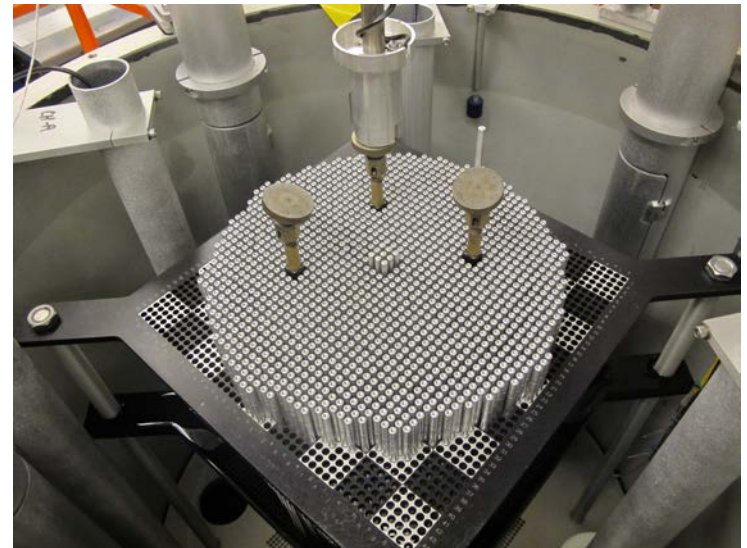
- Fuel Rod
- Empty Grid Location
- Aluminum Experiment Rod



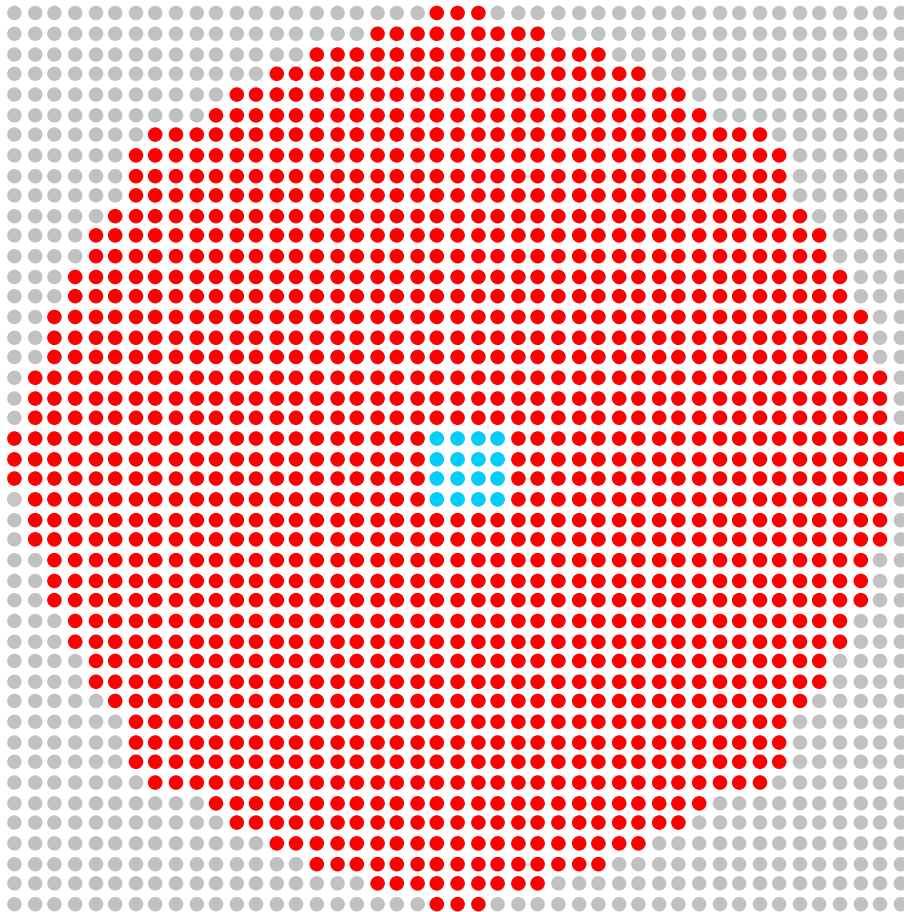
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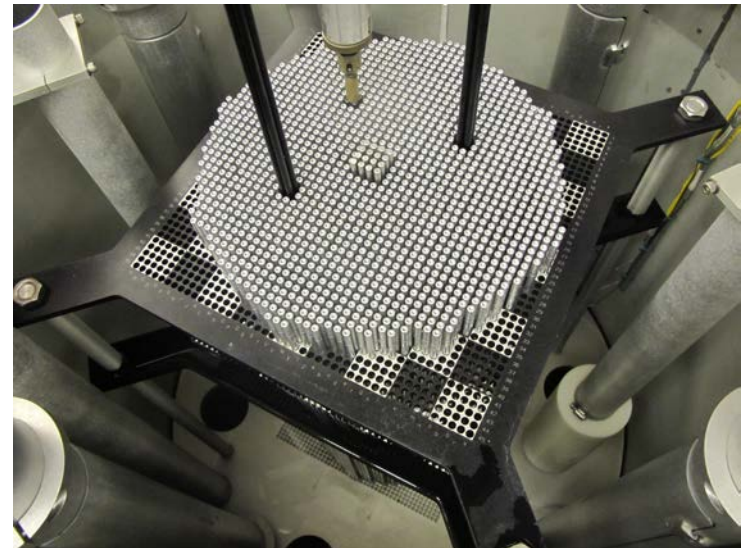
- Fuel Rod
- Empty Grid Location
- Aluminum Experiment Rod



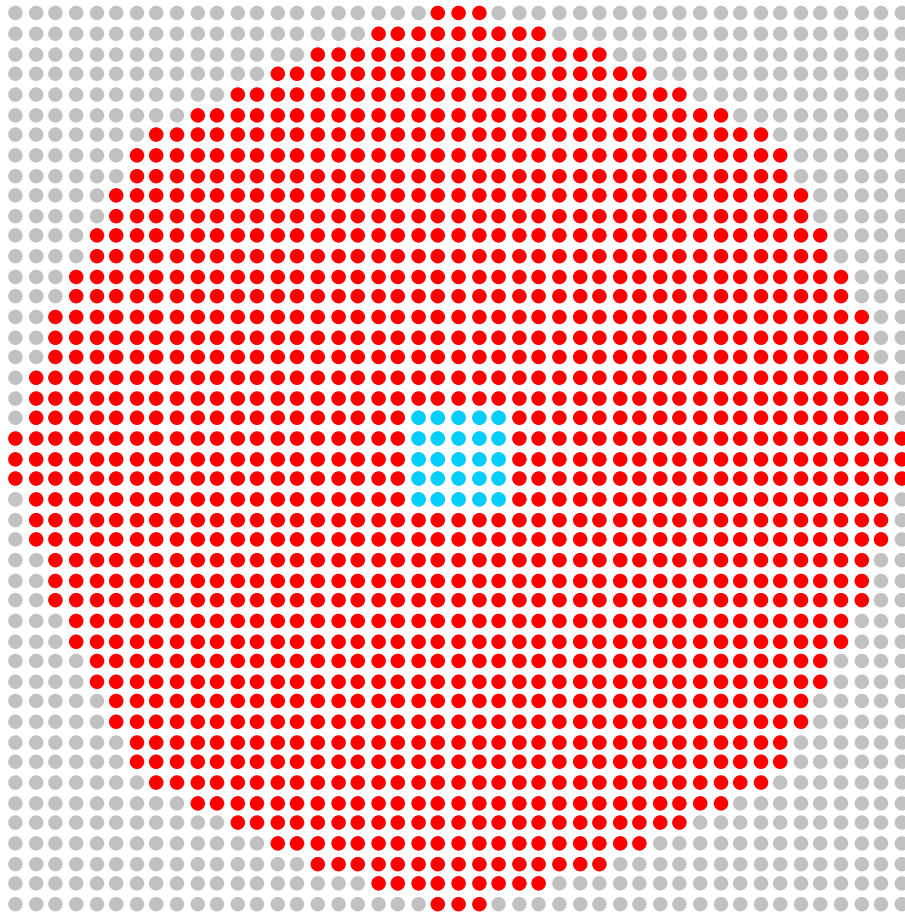
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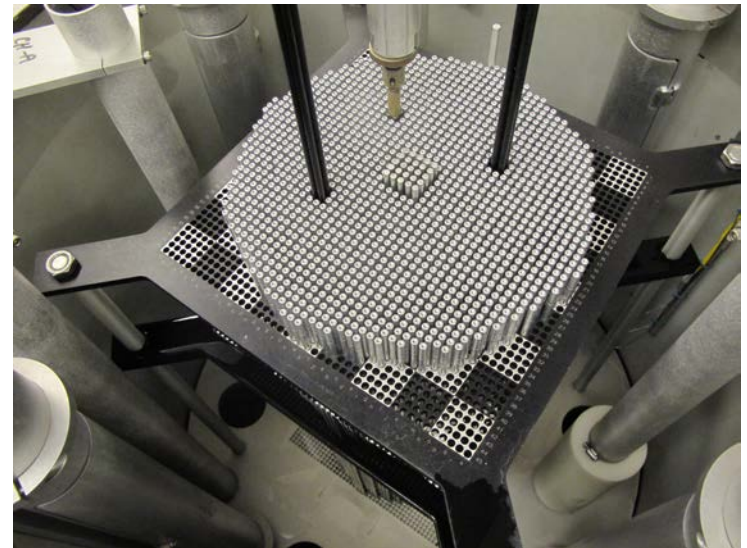
- Fuel Rod
- Empty Grid Location
- Aluminum Experiment Rod



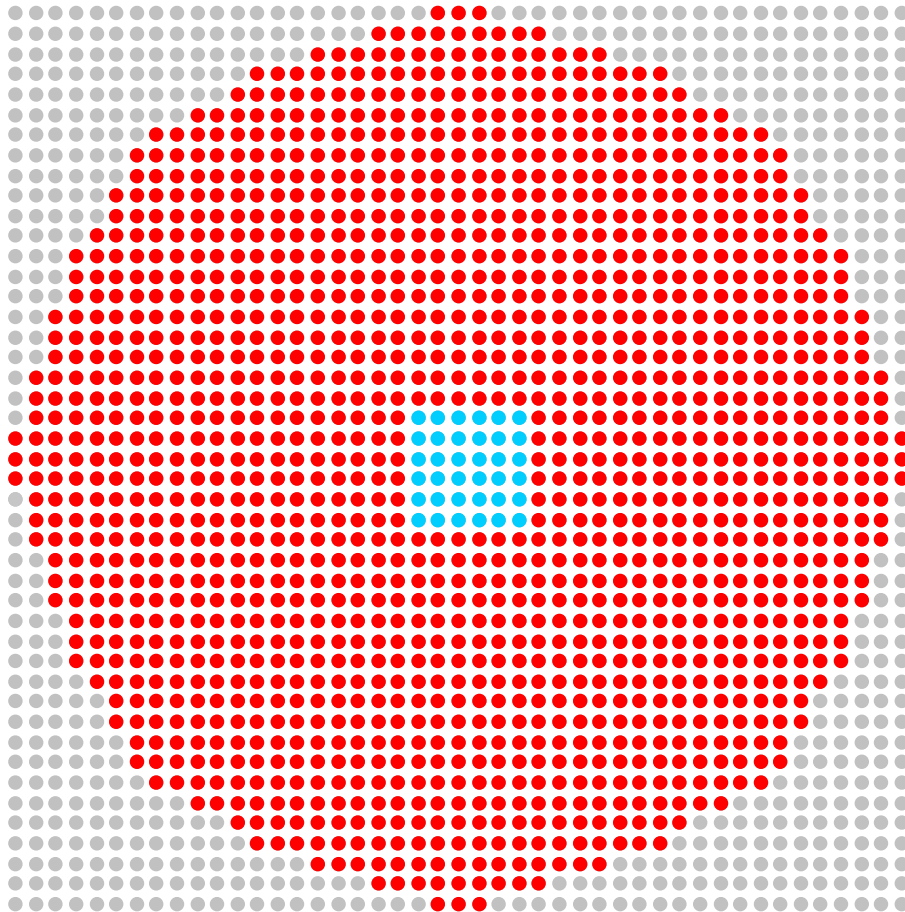
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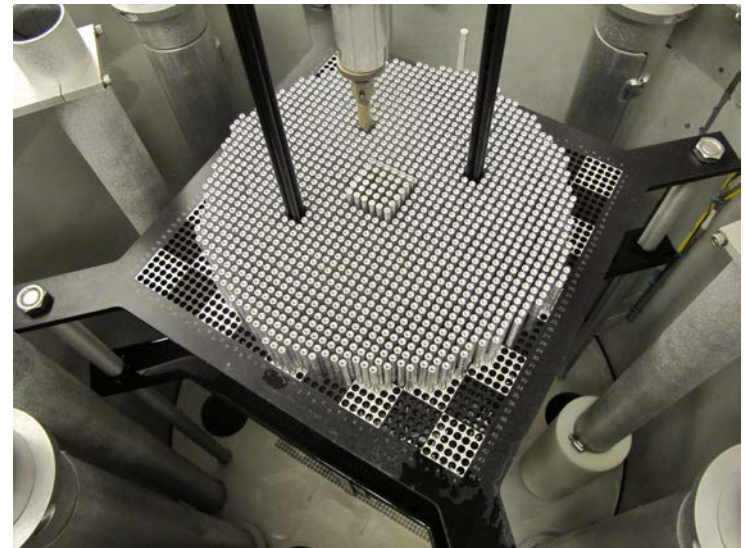
- Fuel Rod
- Empty Grid Location
- Aluminum Experiment Rod



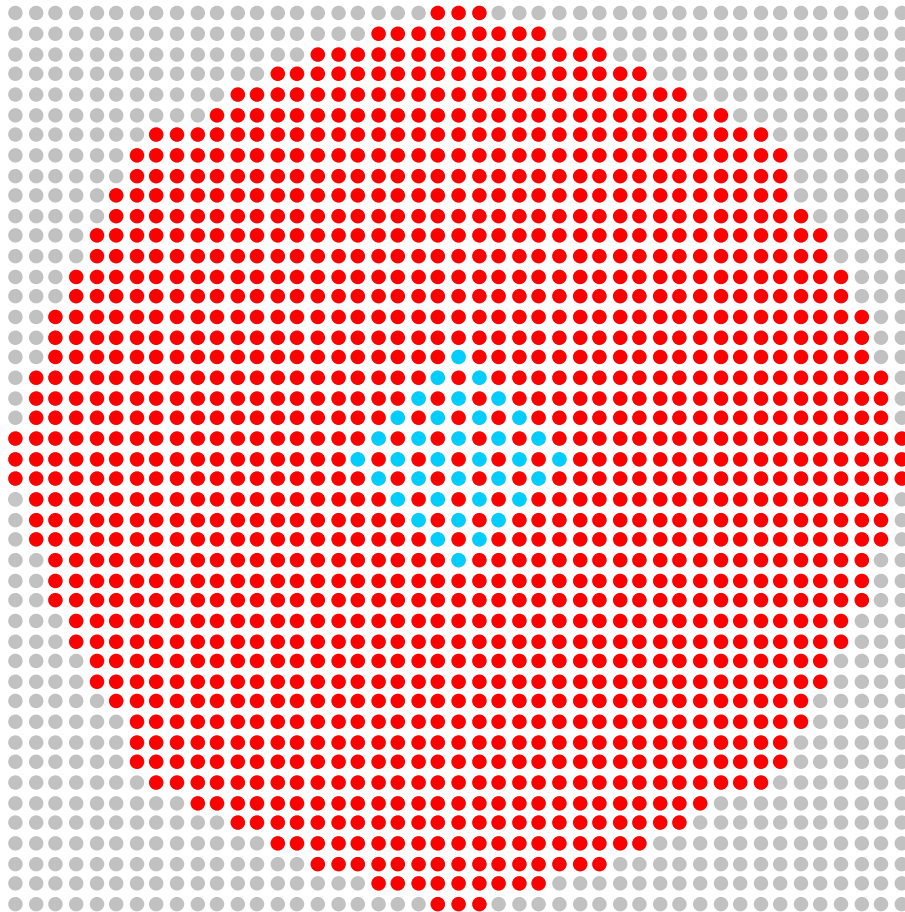
Case 14



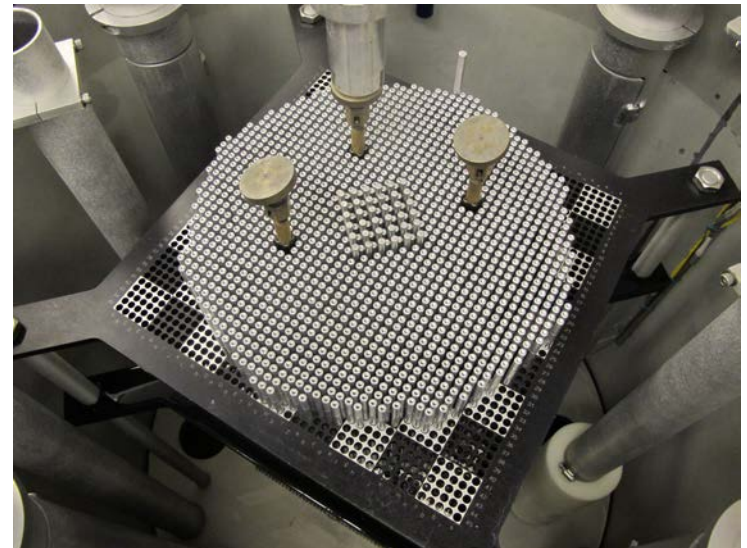
- Fuel Rod
- Empty Grid Location
- Aluminum Experiment Rod



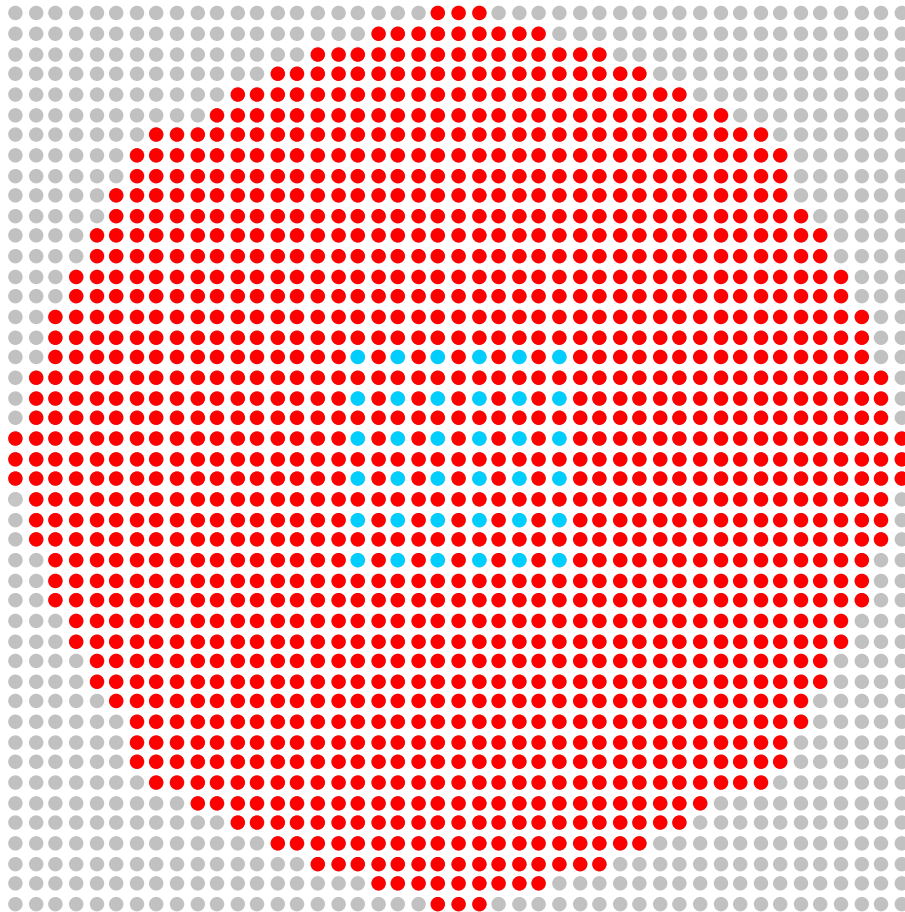
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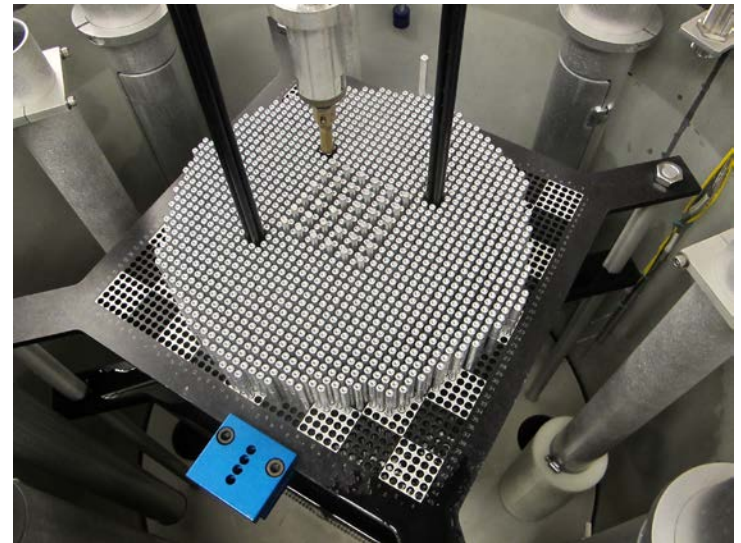
- Fuel Rod
- Empty Grid Location
- Aluminum Experiment Rod



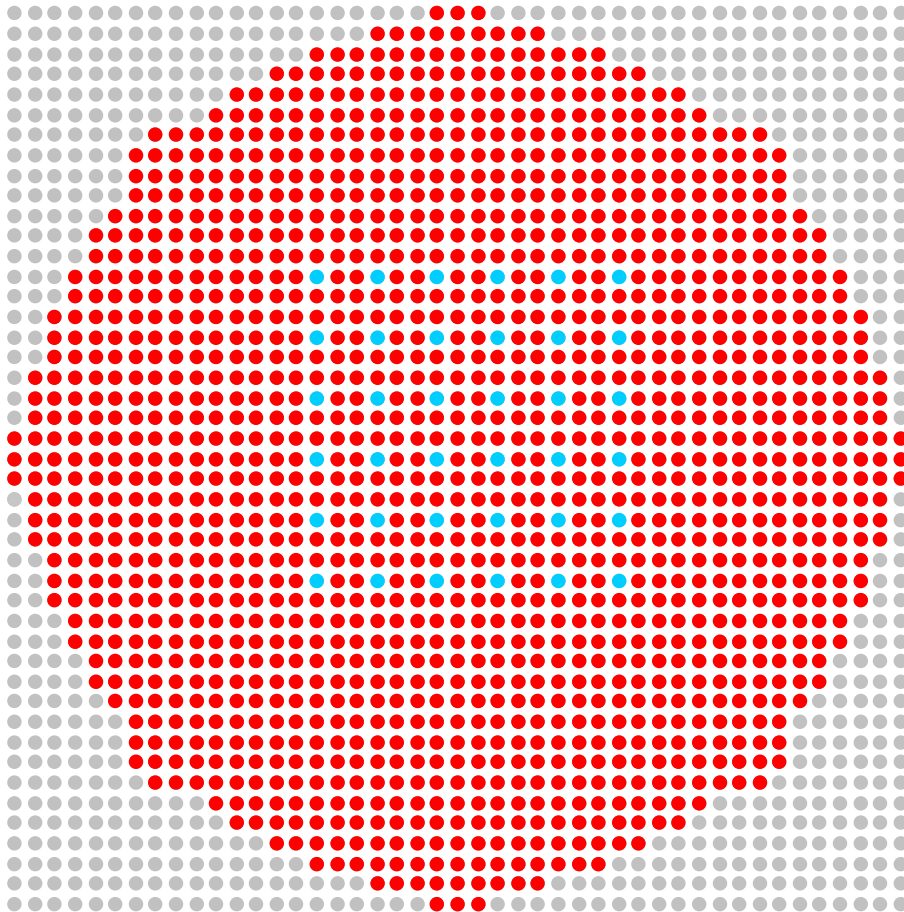
Case 16



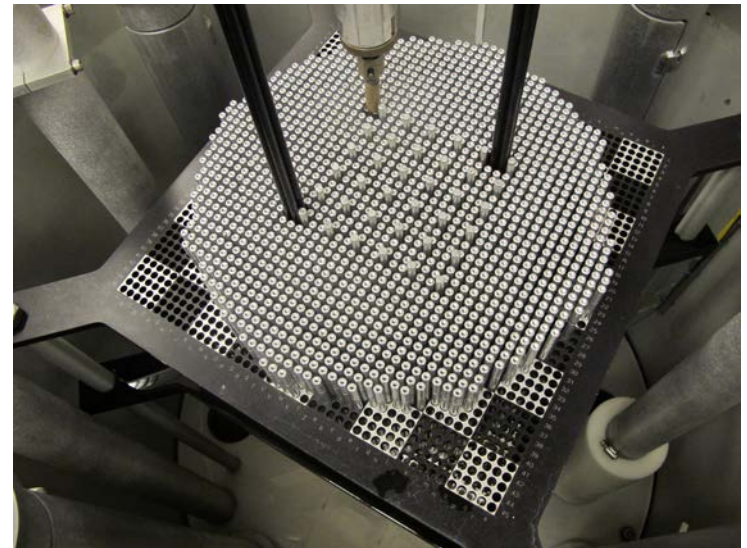
- Fuel Rod
- Empty Grid Location
- Aluminum Experiment Rod



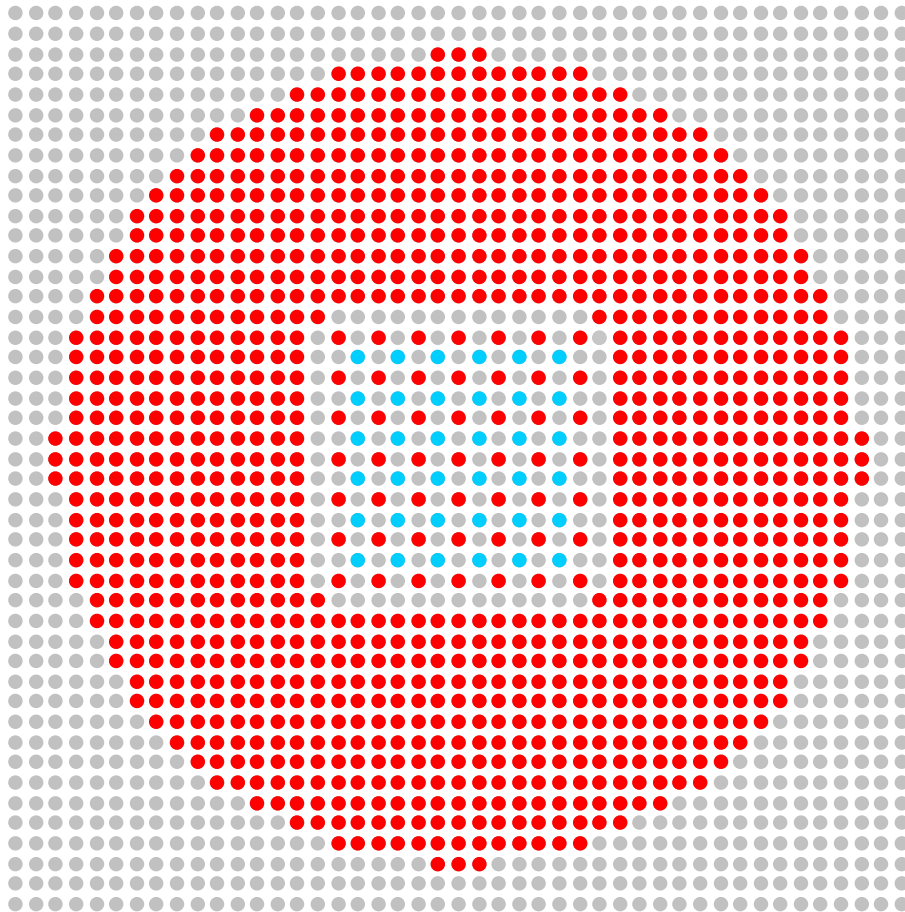
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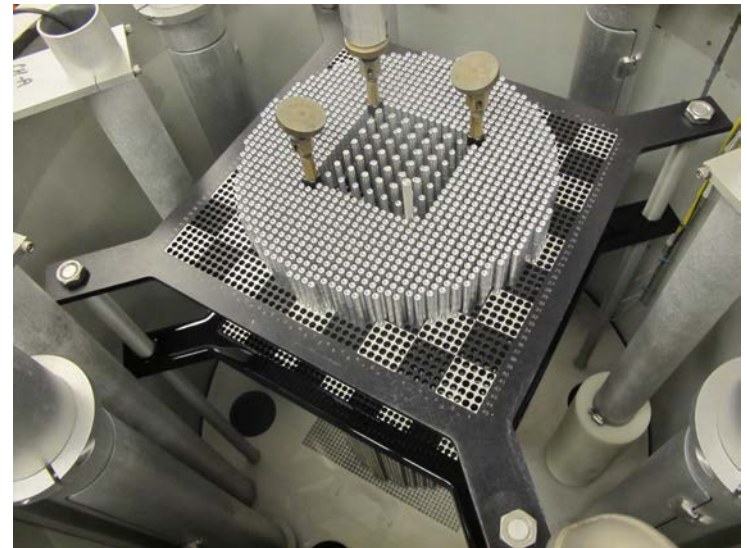
- Fuel Rod
- Empty Grid Location
- Aluminum Experiment Rod



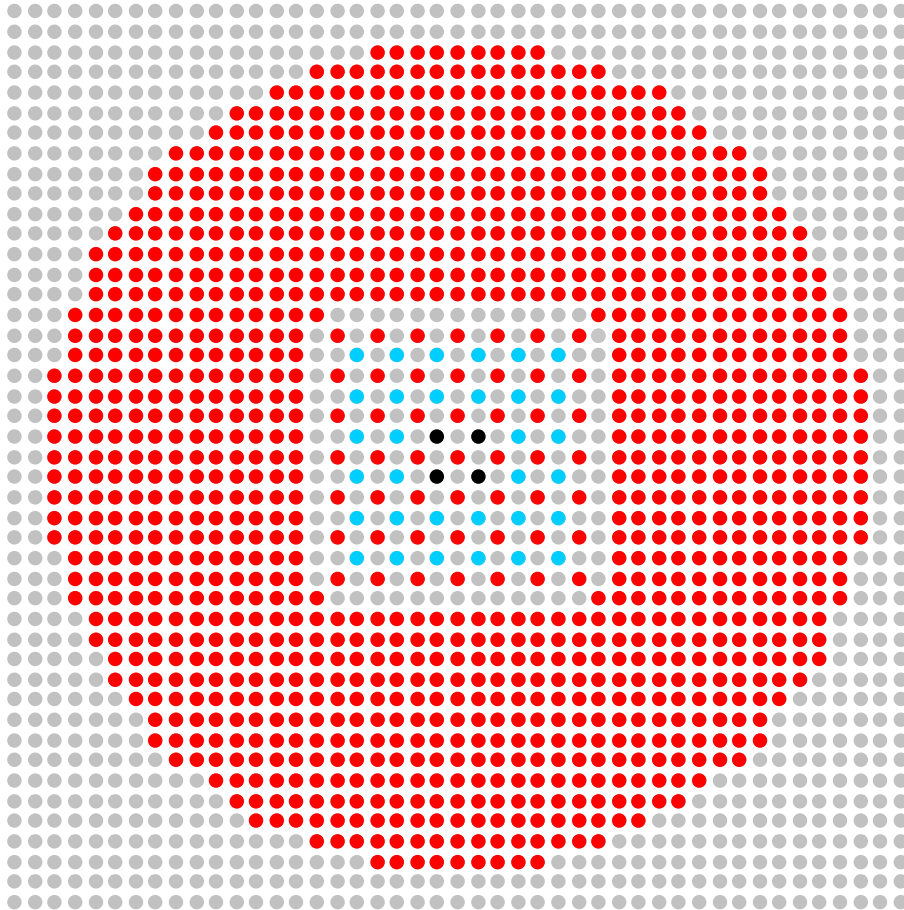
Case 18



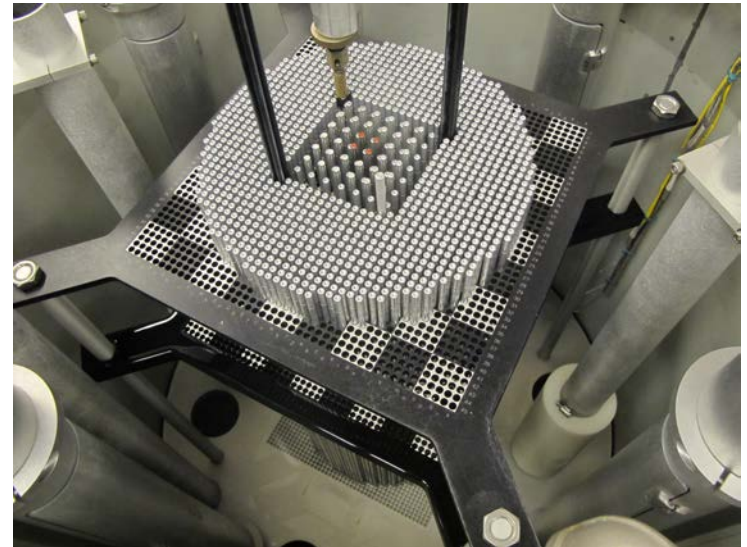
- Fuel Rod
- Empty Grid Location
- Aluminum Experiment Rod



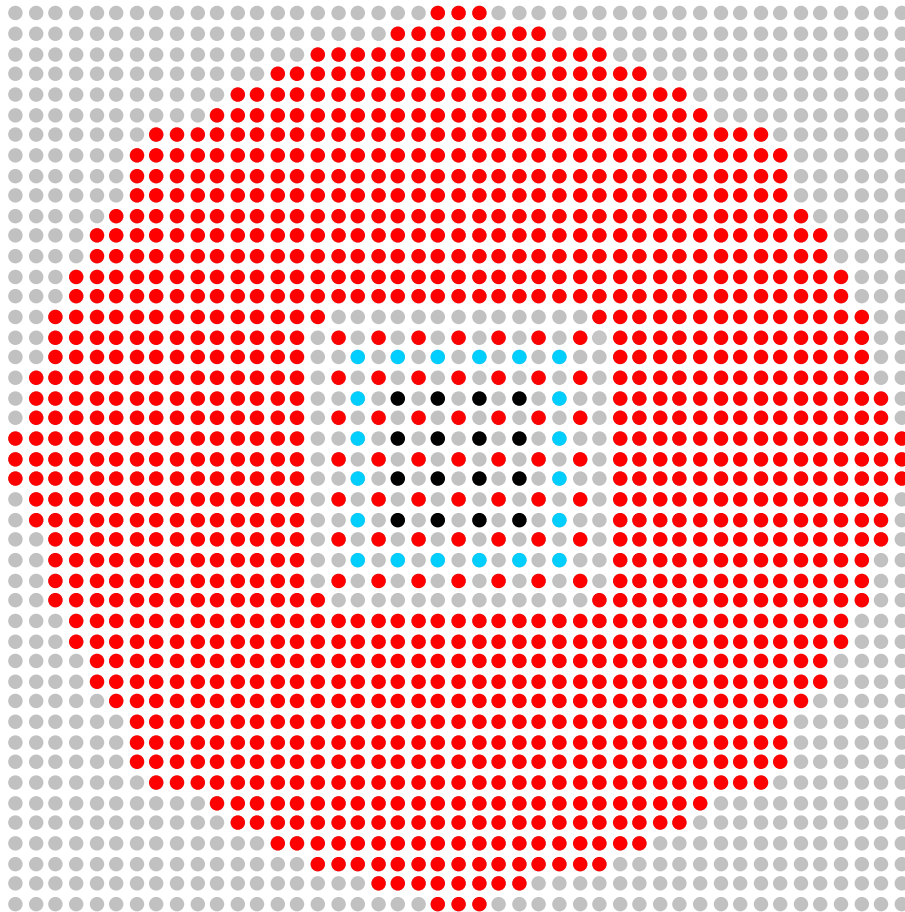
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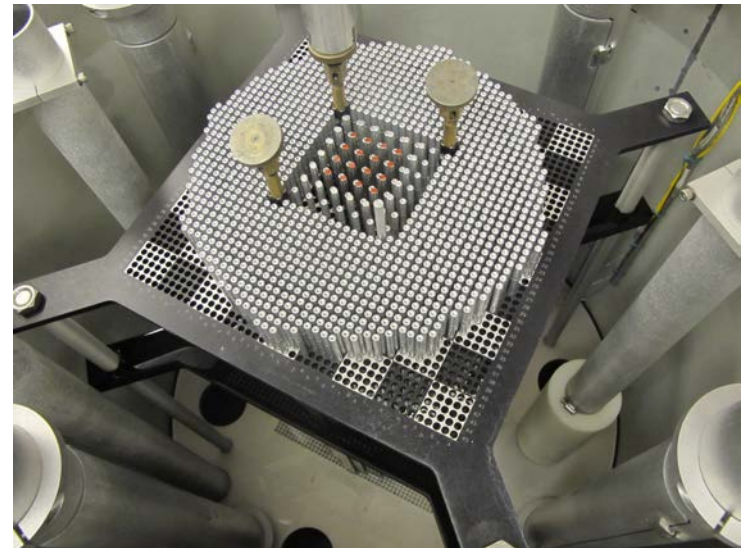
- Fuel Rod
- Empty Grid Location
- Titanium Experiment Rod
- Aluminum Experiment Rod



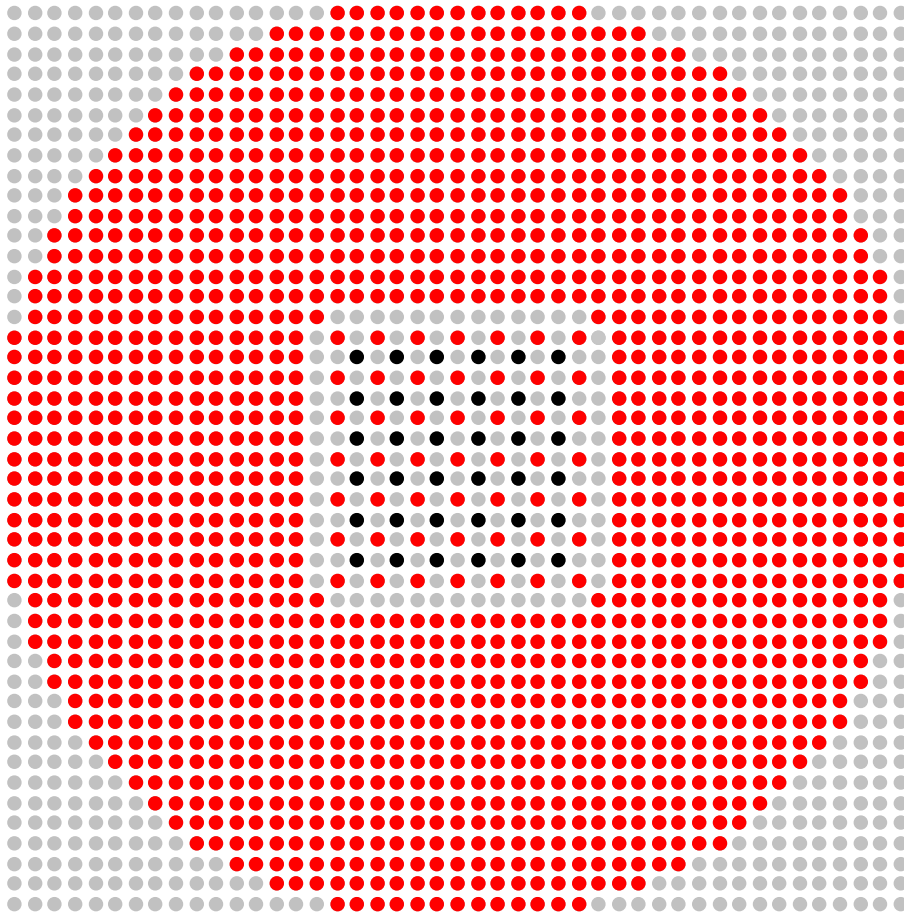
Case 20



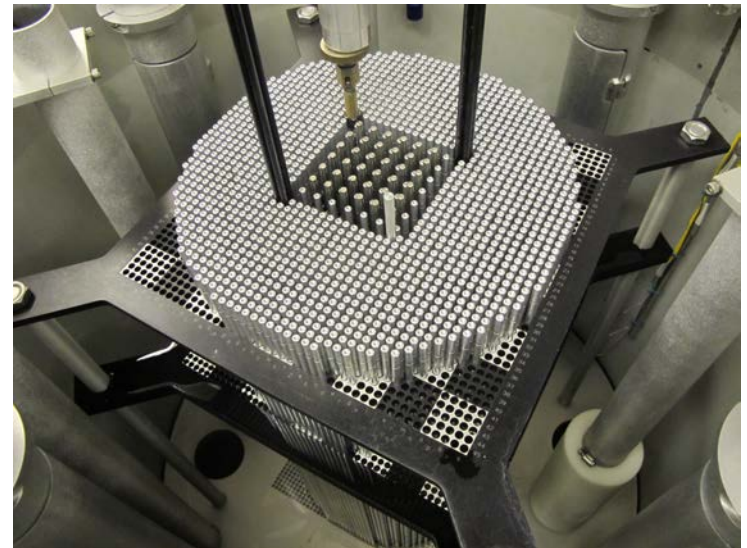
- Fuel Rod
- Empty Grid Location
- Titanium Experiment Rod
- Aluminum Experiment Rod



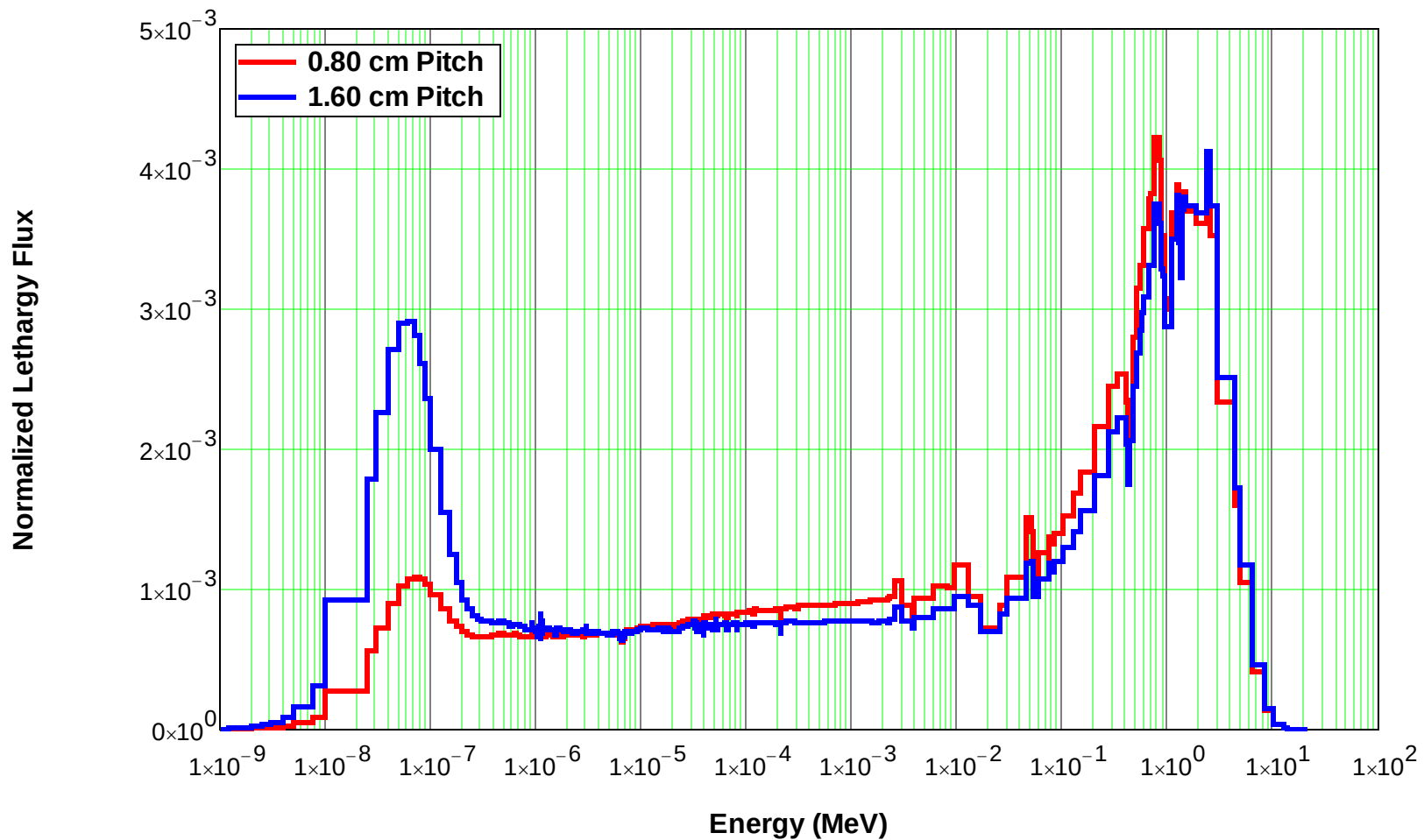
Case 21



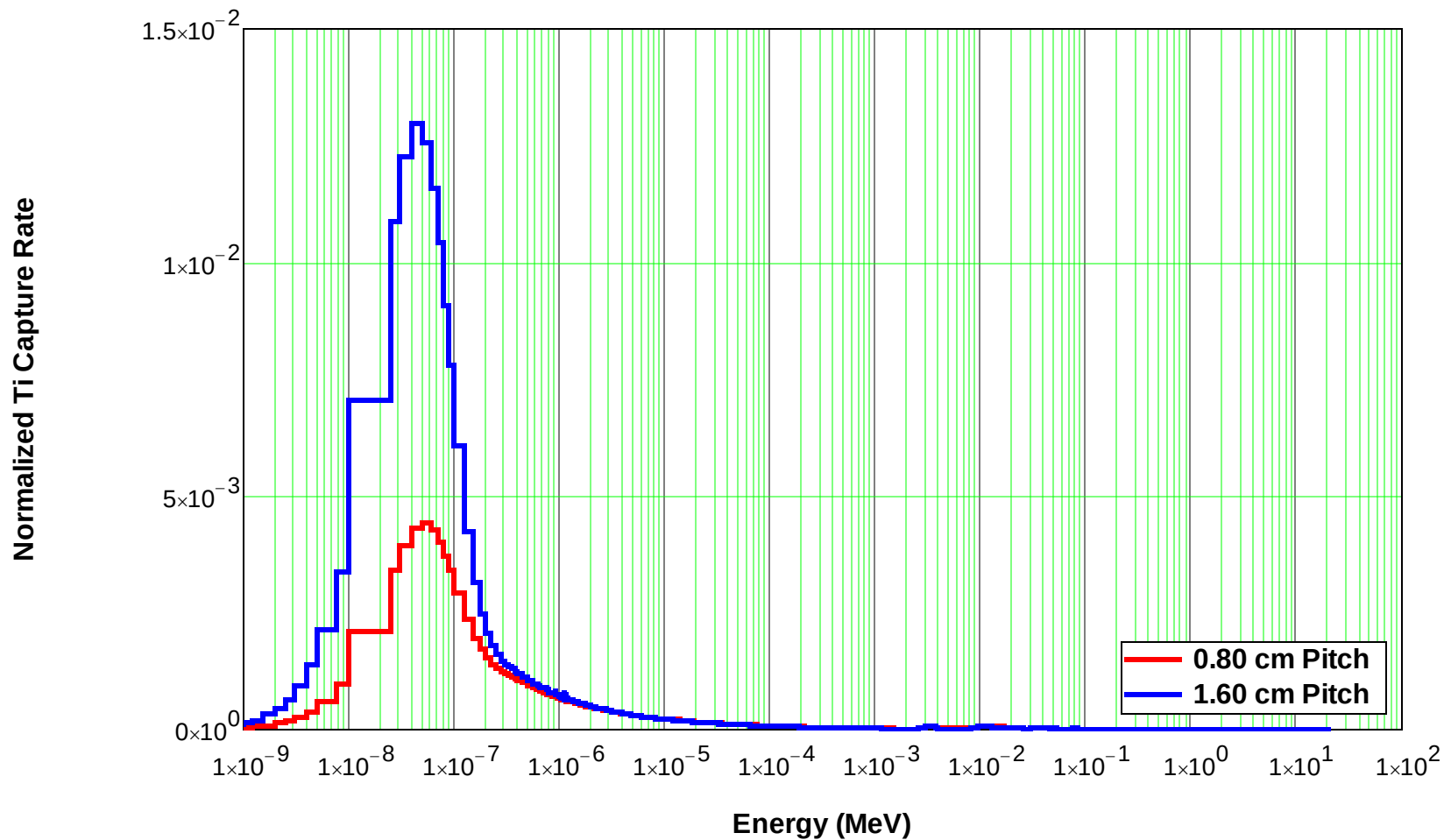
- Fuel Rod
- Empty Grid Location
- Titanium Experiment Rod



A comparison of the neutron spectra in the titanium rods

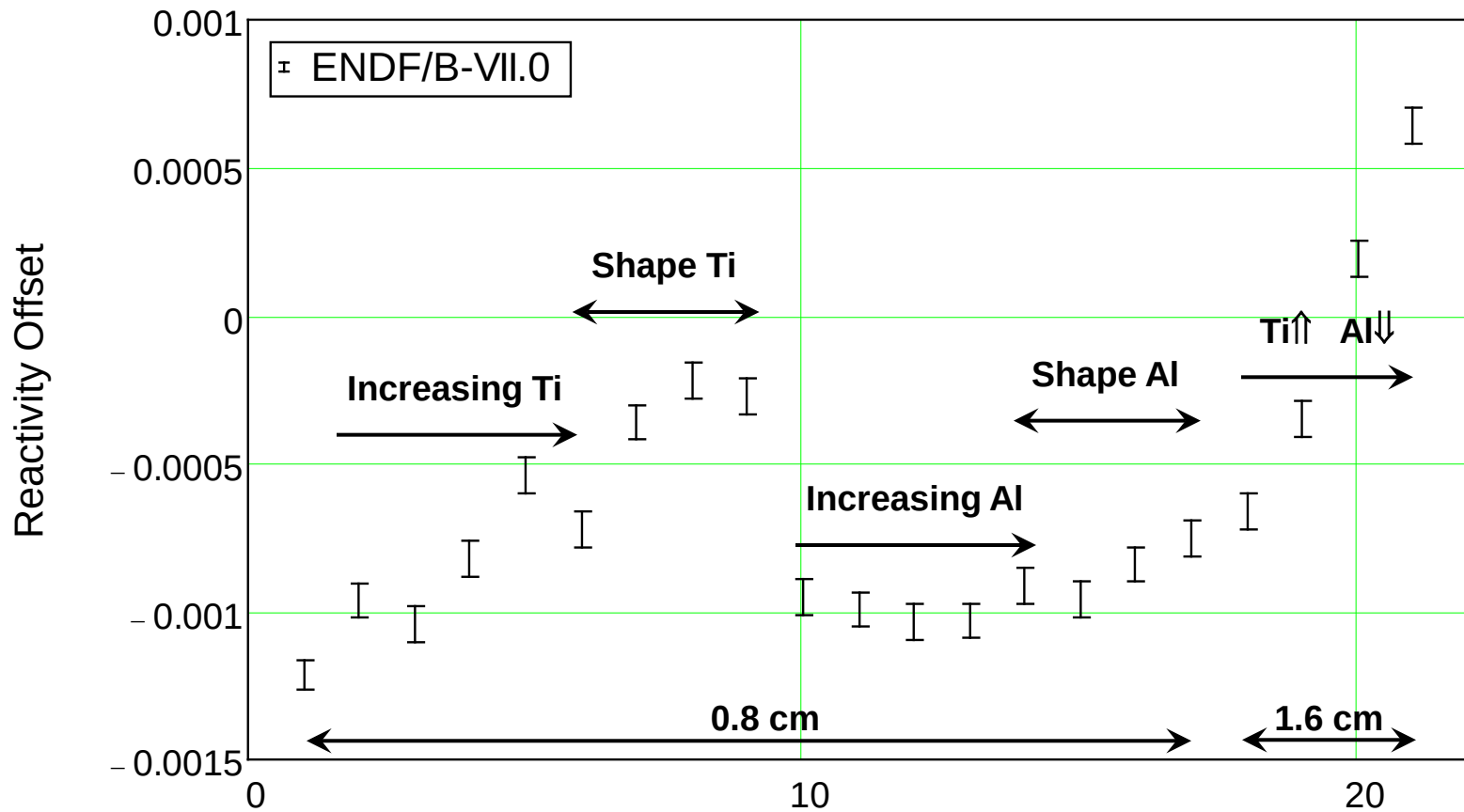


A comparison of the capture rate in the titanium rods



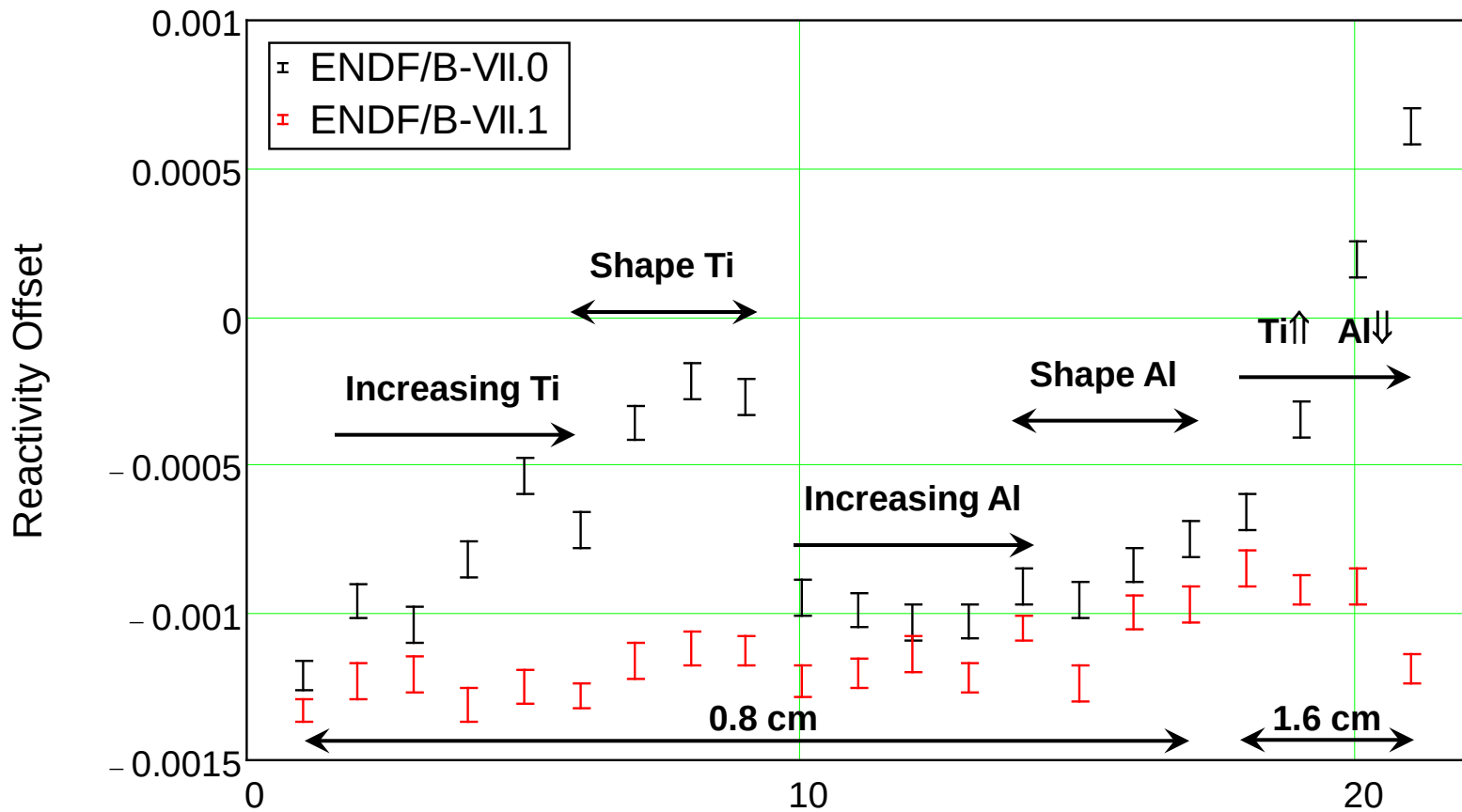
MCNP6.1.1 + ENDF/B-VII.0

Calculation of Benchmark Models



Ti	0	4	9	16	25	36	36	36	36	0	0	0	0	0	0	0	0	4	16	36	
Al	0	0	0	0	0	0	0	0	0	4	9	16	25	36	36	36	36	36	32	20	0
C	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21

Add ENDF/B-VII.1



Ti	0	4	9	16	25	36	36	36	36	0	0	0	0	0	0	0	0	4	16	36	
Al	0	0	0	0	0	0	0	0	0	4	9	16	25	36	36	36	36	32	20	0	
C	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21

The bottom line in the LCT097 evaluation

Case	Experiment		Temperature Correction		Simplification Bias		Experiment Uncertainty	Benchmark Model	
	k_{eff}	Unc.	Δk_{eff}	Unc.	Δk_{eff}	Unc.		k_{eff}	Unc.
1	0.99927	0.00010	0.00000	0.00004	0.00000	0.00000	0.00108	0.99927	0.00109
2	0.99942	0.00012	0.00000	0.00004	0.00000	0.00000	0.00098	0.99942	0.00099
3	0.99933	0.00011	0.00000	0.00004	-0.00001	0.00000	0.00098	0.99932	0.00098
4	0.99947	0.00011	0.00007	0.00004	-0.00001	0.00000	0.00098	0.99953	0.00098
5	0.99941	0.00011	0.00006	0.00004	0.00000	0.00000	0.00098	0.99947	0.00098
6	0.99964	0.00010	0.00005	0.00004	0.00000	0.00000	0.00098	0.99969	0.00098
7	0.99946	0.00011	0.00006	0.00004	-0.00001	0.00000	0.00098	0.99951	0.00098
8	0.99956	0.00014	0.00005	0.00004	0.00000	0.00000	0.00098	0.99961	0.00099
9	0.99948	0.00011	-0.00002	0.00004	0.00000	0.00000	0.00098	0.99946	0.00098
10	0.99913	0.00010	0.00000	0.00004	0.00000	0.00000	0.00106	0.99913	0.00107
11	0.99911	0.00010	-0.00002	0.00004	0.00000	0.00000	0.00106	0.99909	0.00107
12	0.99925	0.00010	0.00005	0.00004	0.00000	0.00000	0.00106	0.99930	0.00107
13	0.99941	0.00009	0.00014	0.00004	0.00000	0.00000	0.00106	0.99955	0.00107
14	0.99936	0.00013	0.00007	0.00004	0.00000	0.00000	0.00106	0.99943	0.00107
15	0.99959	0.00009	0.00012	0.00004	-0.00001	0.00000	0.00106	0.99970	0.00107
16	0.99981	0.00009	-0.00004	0.00004	-0.00001	0.00000	0.00106	0.99976	0.00107
17	0.99944	0.00010	0.00001	0.00004	-0.00001	0.00000	0.00106	0.99944	0.00107
18	0.99938	0.00012	0.00013	0.00004	0.00001	0.00000	0.00077	0.99952	0.00078
19	0.99957	0.00013	0.00009	0.00004	0.00001	0.00000	0.00077	0.99967	0.00078
20	0.99946	0.00010	0.00000	0.00004	0.00001	0.00000	0.00083	0.99947	0.00083
21	0.99961	0.00010	0.00006	0.00004	0.00001	0.00000	0.00083	0.99968	0.00083

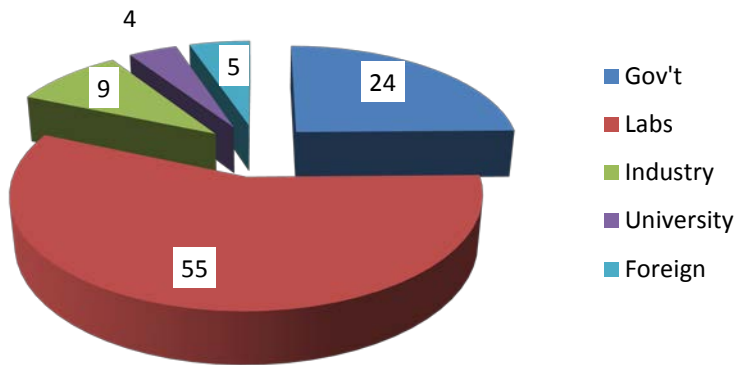


Hands-On Criticality Safety Training at Sandia

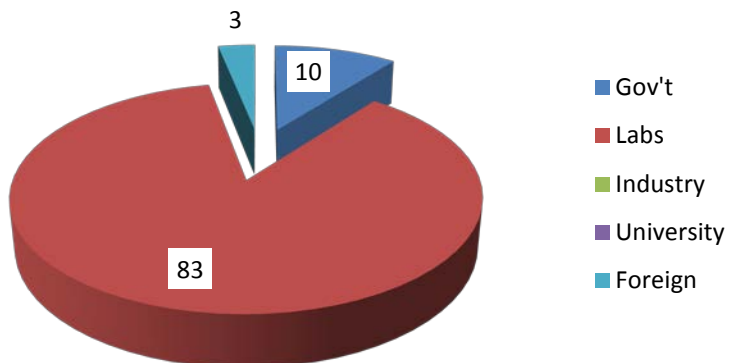
- Two hands-on critical experiment classes are currently offered.
- The first is part of a two-week class for Nuclear Criticality Safety Professionals, 1 week at LANL and one week at Sandia or at NCERC.
- The other is a one-week class at Sandia for Nuclear Material Managers.
- Information about the classes and how to register is at <http://ncsp.llnl.gov/classMain.html>

The Classes Continue to serve a Diverse Audience

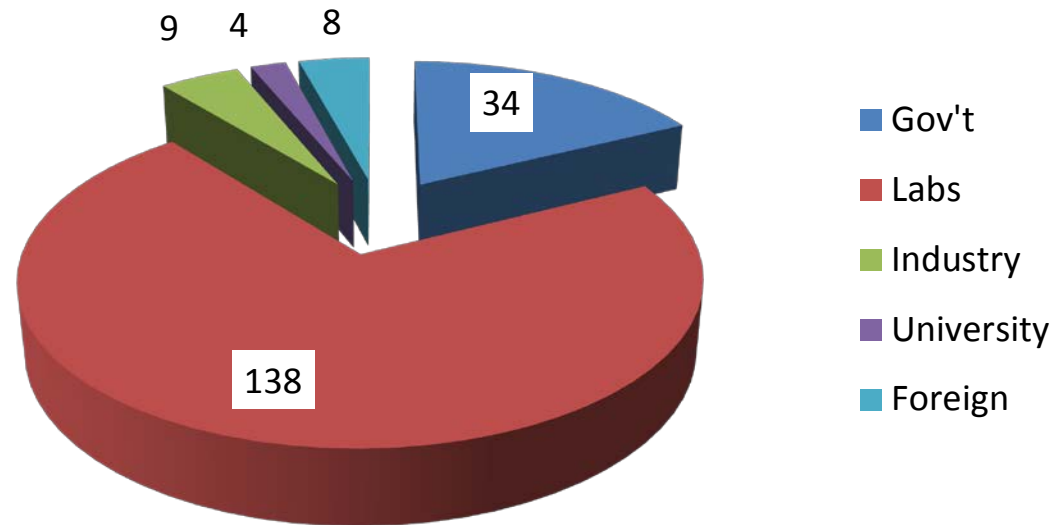
Nuclear Criticality Safety Professionals 11 Sessions, 97 Students



Nuclear Material Managers 7 Sessions, 96 Students



Both Classes 18 Sessions, 193 Students





The Sandia Classes

- The Sandia classes are a series of four experiments
 - Approach on fuel
 - Approach on moderator height
 - “Split table” approach
 - Fuel removal approach
- Lectures on various subjects are integrated with the experiments
- Remember: <http://ncsp.llnl.gov/classMain.html>

Critical Experiments at Sandia

