Epithermal/Intermediate spectrum critical experiment design using SPR/CX

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Overview

- Goal: design an epithermal-intermediate cross section testing capability using the SPR/CX facility at Sandia National Laboratories
- Intermediate spectra cross sections must meaningfully contribute to thermal reactor k_{eff}
  - Epithermal subcritical reactor
  - Thermal critical reactor
- Substitution experiments allow for highlighting a reasonably minor effect
- Thermal self-shielding and integration of thermal neutron-absorbing central region will be used to tailor the absorption reaction rate profile

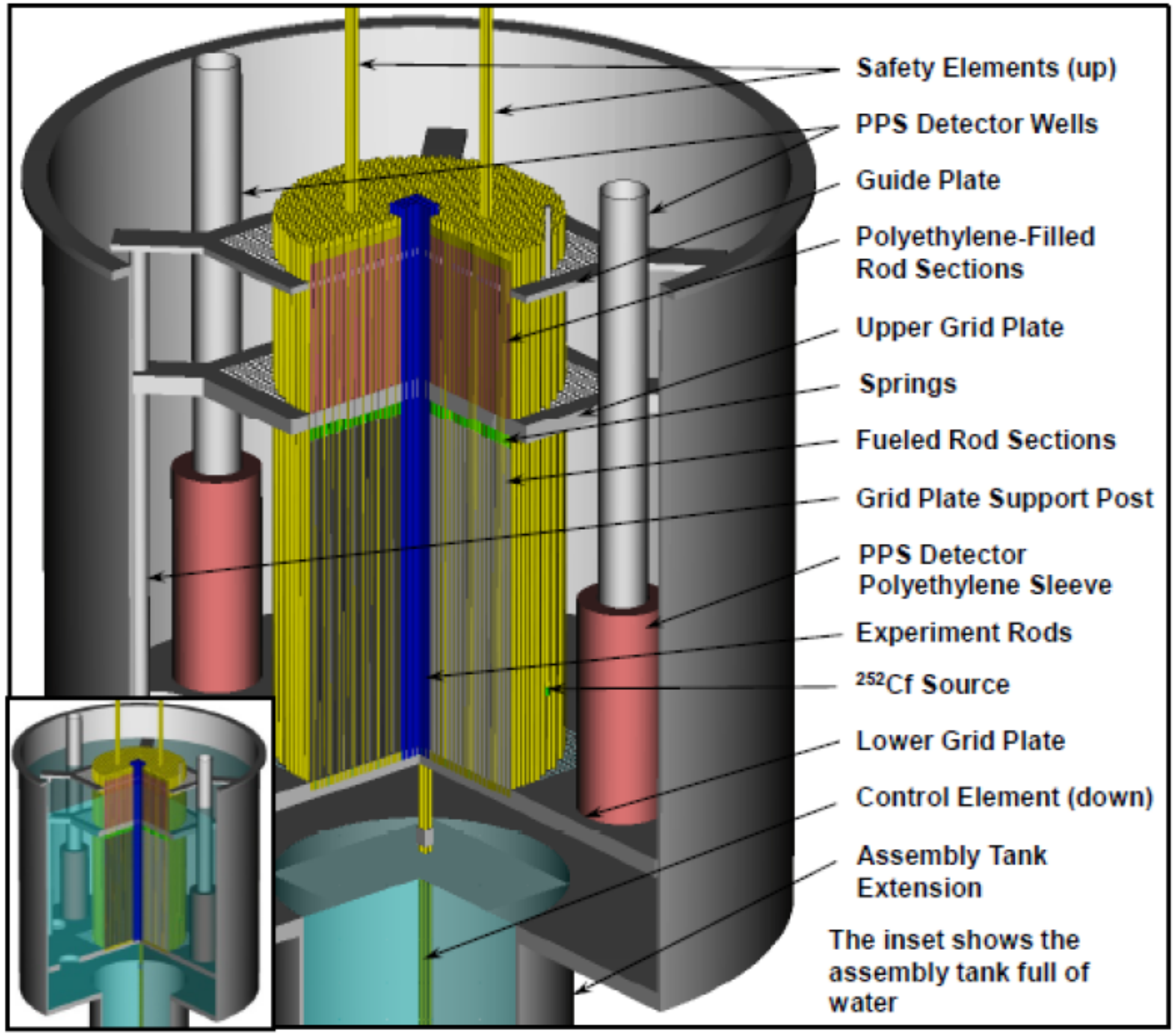
Overview

- $C_E dT$ process overview
- SPR/Cx Apparatus description
- Proposed lattice description
- Conceptual design
- Detailed design
- Outcomes from detailed design so far

C_EdT Process

- CED-0 – Justification of need
- **CED-1- Preliminary Design – FY17**
- **CED-2 – Detailed Design – FY18**
- CED-3a/b – Cost estimates and execution of experiment
- CED-4a/b – Publication and approval

SPR/CX Apparatus



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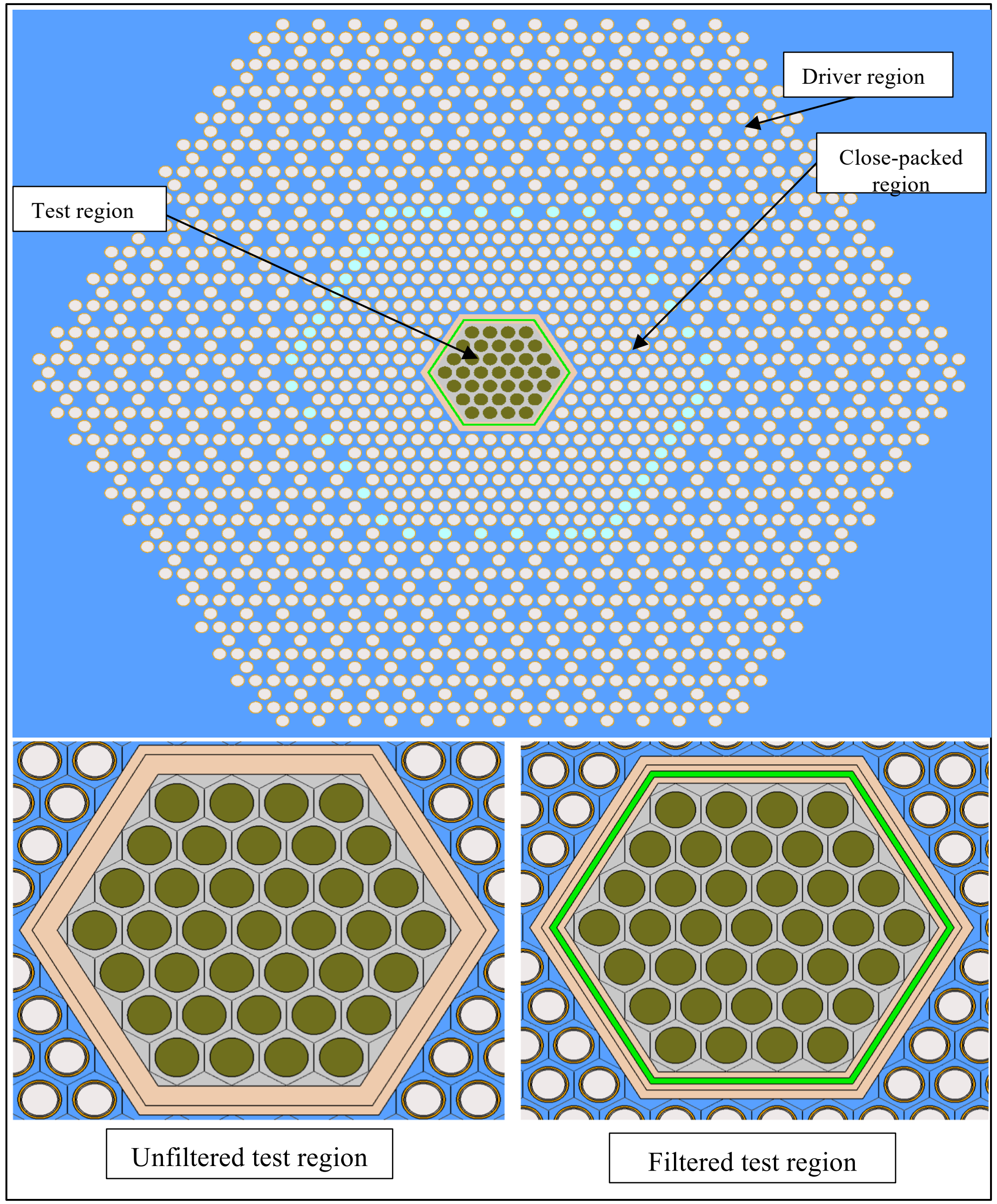
Lattice Design

- 7uPCX Fuel
  - 6.90 wt. % UO_2 fuel
  - 0.25" clad OD/0.315" pitch
- 3 region lattice design
  - Driver region – every other pin removed
  - Close packed region
  - Test Region
- Test region
  - Removable- unfiltered / Cd flux filter
  - Previously proposed B-Al



CED-1: Concept assessment

1. Run calculations for a large number of potential test materials
2. Determine the worth for a fully loaded test region with and without boron present to determine measurability
3. Observe the change in the reaction rate spectrum with the addition of the number of rods and the addition of boron to the block
4. Determine which materials would be best to use in testing

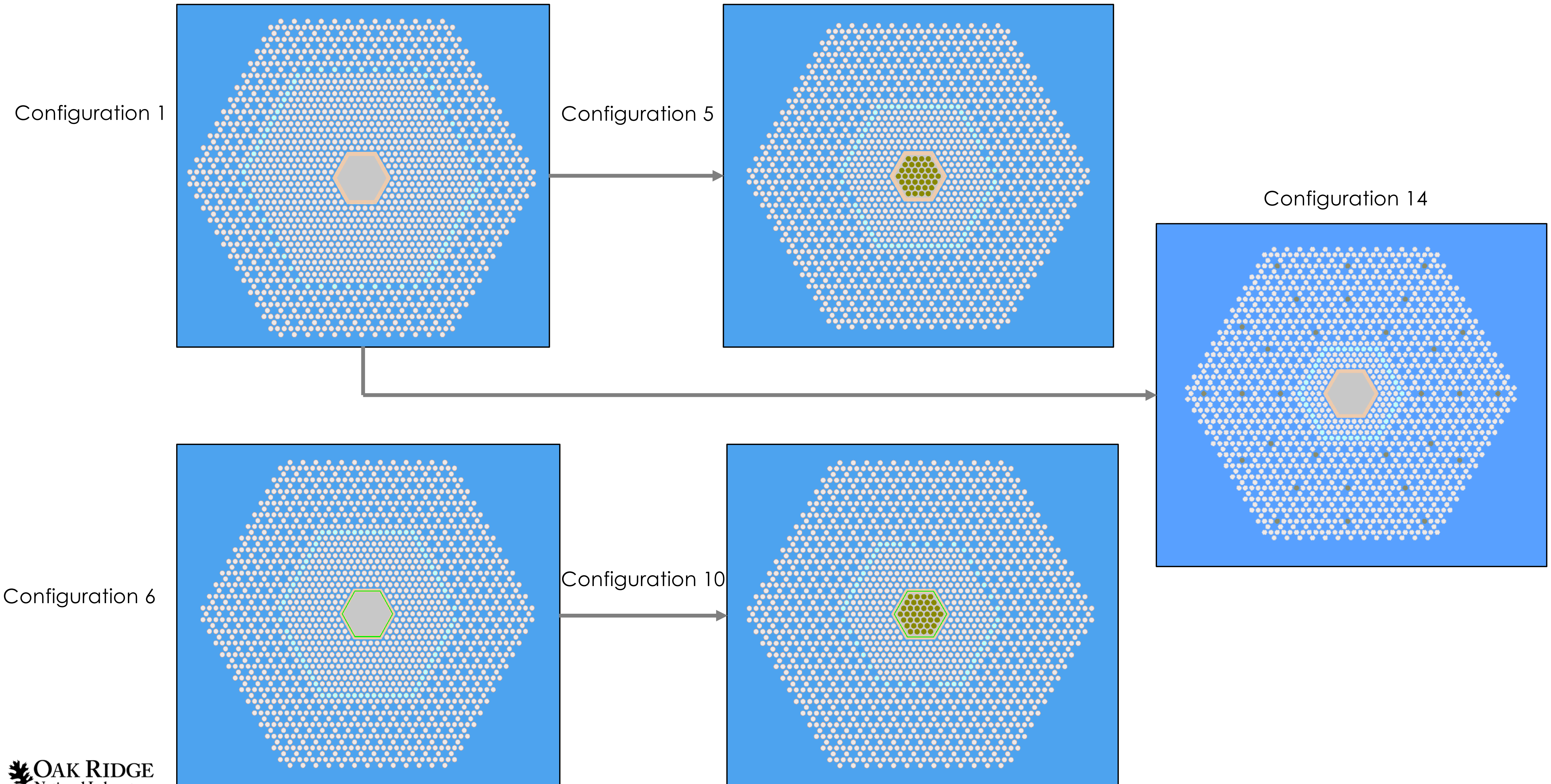
CED-1 qualitative results

Material	Qualitative result
Dysprosium (Dy)	Good
Indium (In)	Good
Hafnium (Hf)	Good
Silver (Ag)	Good
Tantalum (Ta)	Good
Antimony (Sb)	Moderately good
Cobalt (Co)	Moderately good
Tungsten (W)	Moderately good
Manganese (Mn)	Fair
Vanadium (V)	Poor
Strontium (Sr)	Poor
Molybdenum (Mo)	Poor
Copper (Cu)	Poor
Chromium (Cr)	Poor
Titanium (Ti)	Poor
Niobium (Nb)	Poor
Tin (Sn)	Poor
Iron (Fe)	Poor
Calcium (Ca)	Poor

CED-2

- Chose Tantalum as the test material
- 14 Configurations
  - 1-5 Unfiltered configurations with increasing number of Ta rods
  - 6-10 Cd filtered configurations with increasing number of Ta rods
  - 11-14 Thermal configuration with Ta rods in driver region
- Removed rods from the driver region in order to compensate for increased absorber worth
  - May use different approach method in practice

Relationship of substitution experiments



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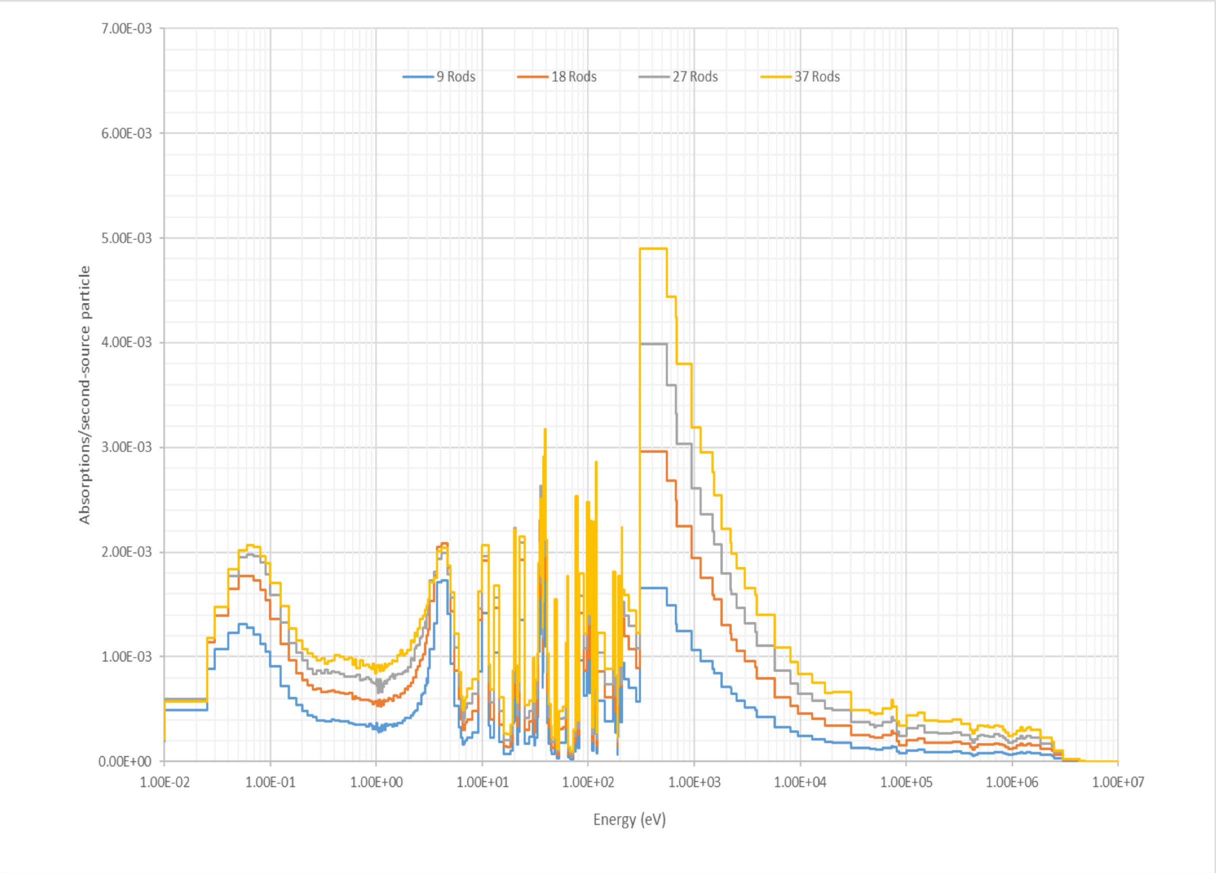
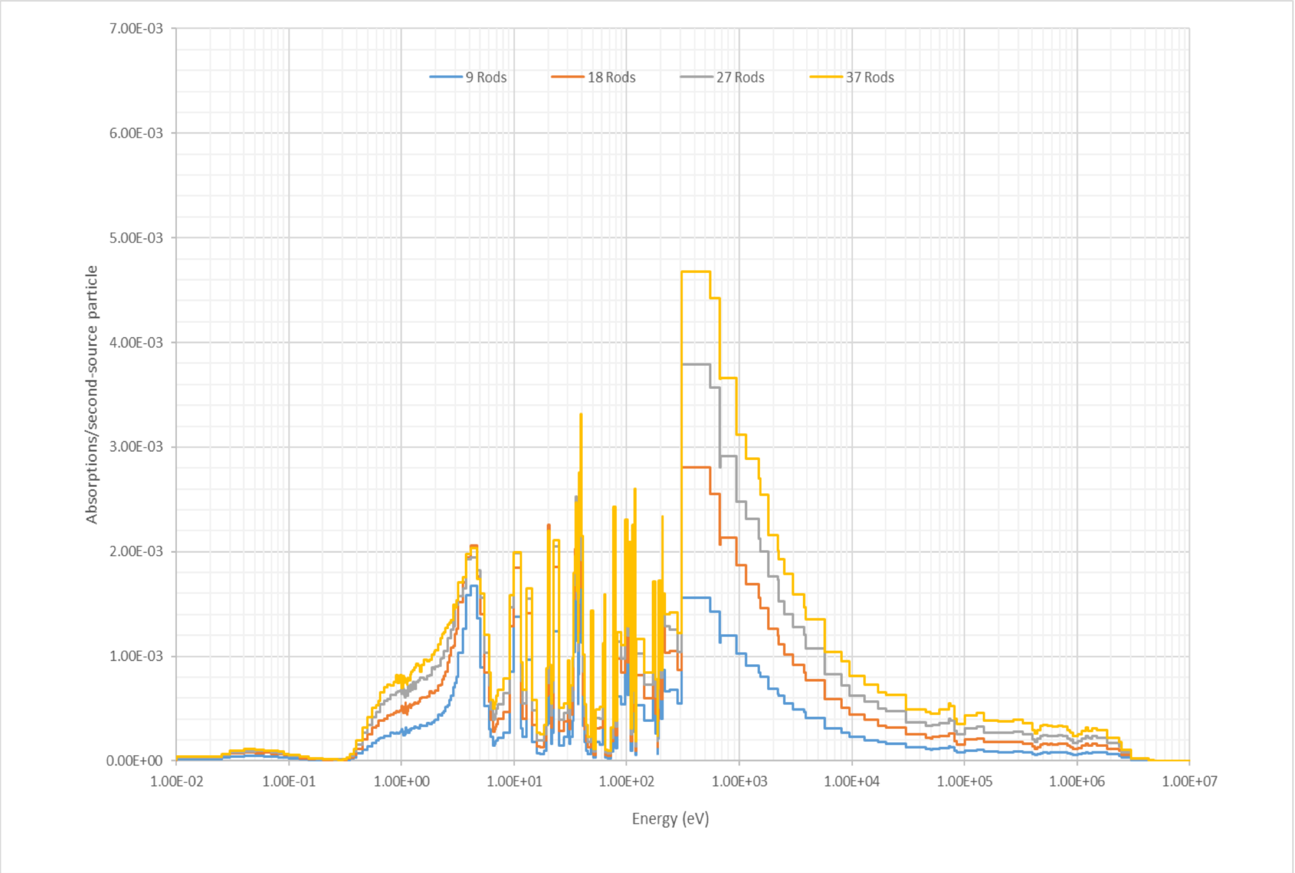
Worths of the Ta test material in the configurations

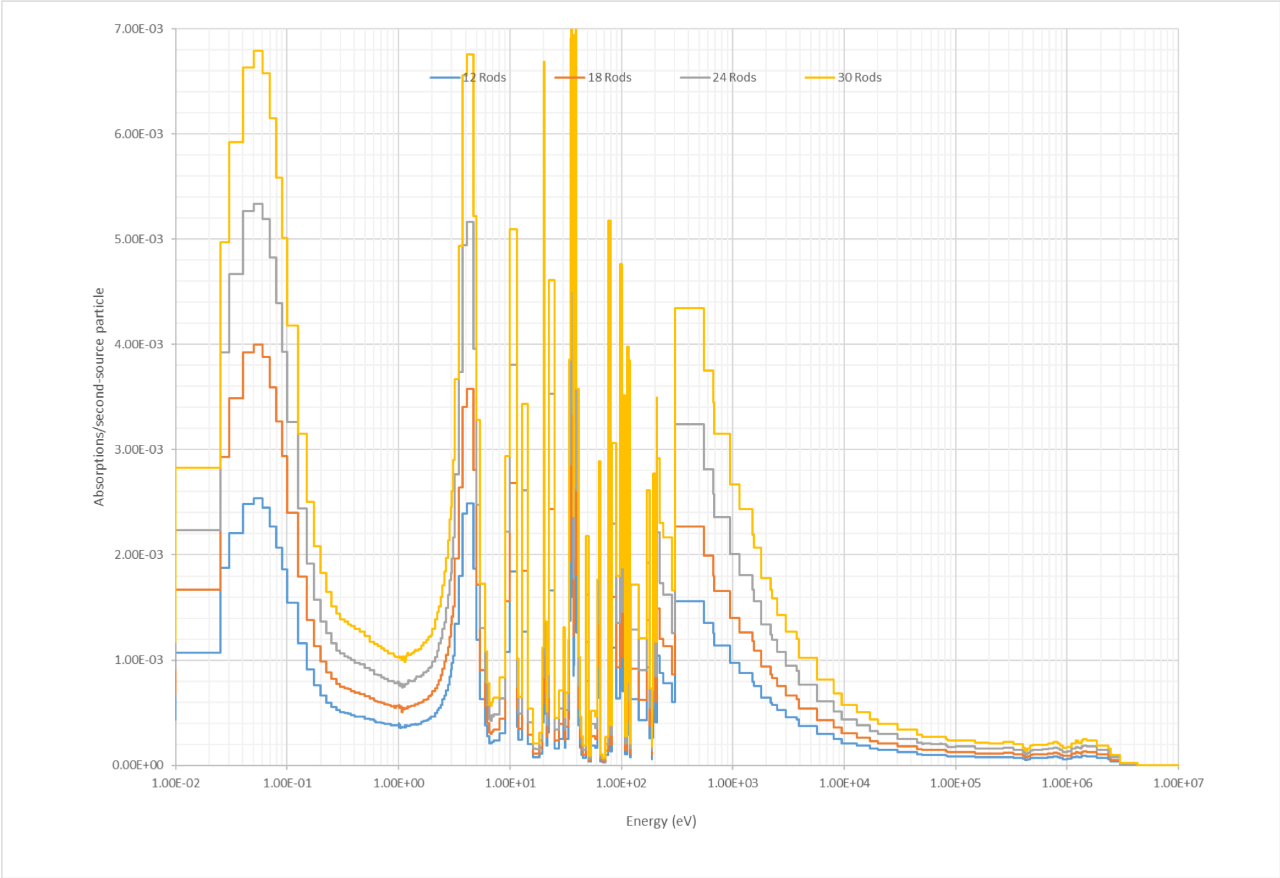
Configuration	$k_{eff} \pm \sigma$	Ta Worth (Δk_{eff}) $\pm \sigma$
1	1.000277 ± 0.000038	0.0
2	0.999758 ± 0.000035	0.01395 ± 0.00011
3	0.99971 ± 0.00011	0.02136 ± 0.00015
4	1.00002 ± 0.00011	0.02597 ± 0.00016
5	1.000105 ± 0.000038	0.02942 ± 0.00012
6	0.999702 ± 0.000037	0.0
7	0.999915 ± 0.000032	0.00767 ± 0.00011
8	1.00003 ± 0.00011	0.01195 ± 0.00016
9	1.00016 ± 0.00011	0.01453 ± 0.00016
10	0.999663 ± 0.000036	0.01666 ± 0.00011
11	0.99991 ± 0.00010	0.01477 ± 0.00016
12	0.99982 ± 0.00012	0.02118 ± 0.00015
13	0.99968 ± 0.00011	0.03059 ± 0.00016
14	1.00056 ± 0.00011	0.04248 ± 0.00015

Unfiltered and filtered configuration reaction rates





Thermal configuration reaction rates



Summary of reaction rate results

Configuration	<1 eV	1eV - 100 eV	100 eV- 1 keV	1keV- 1MeV	>1 MeV
1	0.0%	0.0%	0.0%	0.0%	0.0%
2	31.0%	26.5%	23.1%	18.6%	0.8%
3	27.6%	24.6%	24.9%	21.9%	0.9%
4	25.3%	22.7%	26.1%	24.8%	1.1%
5	23.1%	21.5%	27.1%	27.1%	1.2%
6	0.0%	0.0%	0.0%	0.0%	0.0%
7	3.6%	36.8%	32.2%	26.3%	1.1%
8	3.7%	32.7%	32.8%	29.4%	1.2%
9	3.8%	29.2%	33.5%	32.1%	1.4%
10	3.7%	26.8%	33.7%	34.3%	1.5%
11	43.7%	25.3%	17.6%	12.8%	0.6%
12	45.4%	24.6%	17.0%	12.4%	0.6%
13	44.0%	25.2%	17.5%	12.7%	0.6%
14	43.0%	25.6%	17.8%	12.9%	0.6%

Other CED-2 Items

- Quantification of experimental uncertainties
  - ~0.00130-0.00150 depending on array
  - About 0.00030 higher than current arrays done at SPR/CX
  - Driven by close packed region
  - Actual uncertainties will be smaller due to component statistics rather than bounding values
- Calculated material sensitivities using TSUNAMI-3D
  - Comparable to those of other designs using SPR/CX
- CED-2 report currently finishing NCSP review

Potential Modifications Based on CED-2 Comments

- Will investigate approach to critical on number of fuel rods
- Will investigate using an existing grid plate in order to minimize cost
- Potentially look at sleeve flux filters around Ta test samples to improve material worth and tailor spectrum

Questions?