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Calculations in Support of JAEA ZEUS Experiments

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This is to report recent calculations in support of the experiments on ZEUS to measure Pb void reactivity.

In this package are LANL simulations which are compared to results reported in “Analysis of Comet HEU/Lead experiment” from the JAEA

Analysis of Comet HEU/Lead experiments

Japan Atomic Energy Agency

Research Group for Nuclear Transmutation System

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LANL model

This configuration is the most recent representation for the expected ZEUS HEU critical assembly.

The Pb plates are 1.2cm thick. But each of these are composed of two 0.594cm thick Pb plates. Of this, 0.442cm is Pb with 0.07874 cm Al clad on top and bottom. Therefore, the Pb/Al is about 73.7% Pb and 26.3% Al fraction by volume (92.2 at.% Pb, 7.8 at.% Al).

The homogenized density is 9.016 g/cm³.

This configuration was run with ENDF 7.1 and JENDL 4.0 libraries.

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JAEA vs LANL model

	Radial position(cm)							Thickness (cm)
	2.54	3.175	4.7625	12.7	19.05	26.67		
29.74595				5.0 in	7.5 in			29.74595
44.17314	Upper Refl.							14.42719
44.37676	Top plate							0.20362
45.58876	Lead			Lead				1.21200
46.80076	Lead			Lead				1.21200
47.10046	HEU			HEU				0.29970
48.31246	Lead			Lead				1.21200
49.52446	Lead			Lead				1.21200
49.82416	HEU			HEU				0.29970
51.03616	Lead			Lead				1.21200
52.24816	Lead			Lead				1.21200
52.54786	HEU			HEU				0.29970
53.75986	Lead			Lead				1.21200
54.97186	Lead			Lead				1.21200
55.27156	HEU			HEU				0.29970
56.48356	Lead			Lead				1.21200
57.69556	Lead			Lead				1.21200
57.99526	HEU			HEU				0.29970
59.20726	Lead			Lead				1.21200
60.41926	Lead			Lead				1.21200
60.71896	HEU			HEU				0.29970
61.93096	Lead			Lead				1.21200
63.14296	Lead			Lead				1.21200
63.44266	HEU			HEU				0.29970
63.70682	Steel Diaphragm (SD)							0.26416
64.91882	Reg.1(Lead or Void)			Lead	Lead			1.21200
65.21854	HEU			HEU				0.29972
66.43054	Reg.2(Lead or Void)			Lead	Lead			1.21200
67.64254	Reg.3(Lead or Void)			Lead	Lead			1.21200
67.94226	HEU			HEU				0.29972
69.15426	Reg.4(Lead or Void)			Lead	Lead			1.21200
70.36626	Reg.5(Lead or Void)			Lead	Lead			1.21200
70.66598	HEU			HEU				0.29972
71.87798	Reg.6(Lead or Void)			Lead	Lead			1.21200
73.08998	Lead			Lead				1.21200
73.3897	HEU			HEU				0.29972
74.6017	Lead			Lead				1.21200
75.8137	Lead			Lead				1.21200
76.11342	HEU			HEU				0.29972
77.32542	Lead			Lead				1.21200
78.53742	Lead			Lead				1.21200
78.83714	HEU			HEU				0.29972
80.04914	Lead			Lead				1.21200
81.26114	Lead			Lead				1.21200
81.56086	HEU			HEU				0.29972
83.05946	NU			NU				1.49860
97.48666	Lower Ref.							14.42720
103.83666	Platen+PAP							6.35000

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JAEA vs LANL model

Comparison:

- Stacking of HEU/Pb slightly off based on different “unit stack” composition.
- LANL model has no “top plate”
- LANL model does not have lower “NU” plate
- Small difference in Pb/Al plates: 1.212 (JAEA) cm vs 1.2cm (LANL).
- Material uncertainties
 - Composition of Pb is the largest uncertainty. Other issues could be in composition of upper reflector, lower reflector and corner and side reflectors.

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K_{eff} Comparison: JAEA Results vs. LANL Model Runs

Same nuclear data, difference due to geometry?

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Pb Void Reactivity Change

Overall, Japanese expectation of Pb void reactivity are smaller in magnitude than LANL simulations.

JENDL40 has smaller Pb void worth than ENDF or JENDL33.

Note: $\Delta k_{\text{eff}} = \frac{k_2 - k_1}{k_2 * k_1}$ is used to match results reported in JAEA slides.

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KSEN Coefficients for Pb, JENDL vs. ENDF

JENDL4				ENDF7.1			
isotope	reaction	sensitivity	rel unc	isotope	reaction	sensitivity	rel unc
82204.40c	total + sab	1.62E-04	1.7711	82204.80c	total + sab	9.46E-04	0.3282
82204.40c	capture	-8.66E-04	0.0019	82204.80c	capture	-4.72E-04	0.0024
82204.40c	elastic	5.99E-04	0.471	82204.80c	elastic	9.85E-04	0.3101
82204.40c	inelastic	4.26E-04	0.1417	82204.80c	inelastic	4.27E-04	0.138
82206.40c	total + sab	2.18E-02	0.0522	82206.80c	total + sab	2.01E-02	0.0569
82206.40c	capture	-2.00E-03	0.0033	82206.80c	capture	-1.97E-03	0.0033
82206.40c	elastic	1.75E-02	0.0632	82206.80c	elastic	1.54E-02	0.0725
82206.40c	inelastic	6.18E-03	0.04	82206.80c	inelastic	6.53E-03	0.0377
82207.40c	total + sab	2.05E-02	0.0565	82207.80c	total + sab	2.17E-02	0.0545
82207.40c	capture	-1.07E-03	0.0033	82207.80c	capture	-1.08E-03	0.0032
82207.40c	elastic	1.60E-02	0.0713	82207.80c	elastic	1.66E-02	0.0697
82207.40c	inelastic	5.33E-03	0.0454	82207.80c	inelastic	5.93E-03	0.0414
82208.40c	total + sab	4.26E-02	0.0416	82208.80c	total + sab	4.31E-02	0.0409
82208.40c	capture	-3.52E-04	0.0018	82208.80c	capture	-4.97E-04	0.0039
82208.40c	elastic	4.02E-02	0.0439	82208.80c	elastic	4.07E-02	0.0432
82208.40c	inelastic	2.35E-03	0.0663	82208.80c	inelastic	2.45E-03	0.0647

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The HEU-MET-FAST-072-001 benchmark was used to check that the LANL MCNP6/JENDL4 libraries give consistent results to JAEA.

Three points are mean value and +/- 1-sigma.

Case	keff	1-sigma
Measurement	0.9991	0.0024
MCNP (Benchmark, ENDF7.1)	1.0087	0.0001
JAEA	1.00552	0.00013
MCNP (ENDF70)	1.0084	0.00003
MCNP(JENDL)	1.00561	0.00003

Results: LANL results match JAEA results with our versions of MCNP and JENDL-4.0 nuclear data. Differences in ZEUS runs **must** be in geometry/materials

JAEA Comparison

Reconfigured LANL ZEUS model to look like JAEA-reported configuration

	Radial position(cm)							Thickness (cm)
	2.54	3.175	4.7625	12.7	19.05	26.67		
29.74595				5.0 in	7.5 in		29.74595	
44.17314	Upper Refl.						14.42719	
44.37676	Top plate						0.20362	
45.58876	Lead			Lead			1.21200	
46.80076	Lead			Lead			1.21200	
47.10046	HEU			HEU			0.29970	
48.31246	Lead			Lead			1.21200	
49.52446	Lead			Lead			1.21200	
49.82416	HEU			HEU			0.29970	
51.03616	Lead			Lead			1.21200	
52.24816	Lead			Lead			1.21200	
52.54786	HEU			HEU			0.29970	
53.75986	Lead			Lead			1.21200	
54.97186	Lead			Lead			1.21200	
55.27156	HEU			HEU			0.29970	
56.48356	Lead			Lead			1.21200	
57.69556	Lead			Lead			1.21200	
57.99526	HEU			HEU			0.29970	
59.20726	Lead			Lead			1.21200	
60.41926	Lead			Lead			1.21200	
60.71896	HEU			HEU			0.29970	
61.93096	Lead			Lead			1.21200	
63.14296	Lead			Lead			1.21200	
63.44266	HEU			HEU			0.29970	
63.70682	Steel Diaphragm (SD)						0.26416	
64.91882	Reg.1(Lead or Void)			Lead	Lead		1.21200	
65.21854	HEU			HEU			0.29972	
66.43054	Reg.2(Lead or Void)			Lead	Lead		1.21200	
67.64254	Reg.3(Lead or Void)			Lead	Lead		1.21200	
67.94226	HEU			HEU			0.29972	
69.15426	Reg.4(Lead or Void)			Lead	Lead		1.21200	
70.36626	Reg.5(Lead or Void)			Lead	Lead		1.21200	
70.66598	HEU			HEU			0.29972	
71.87798	Reg.6(Lead or Void)			Lead	Lead		1.21200	
73.08998	Lead			Lead			1.21200	
73.3897	HEU			HEU			0.29972	
74.6017	Lead			Lead			1.21200	
75.8137	Lead			Lead			1.21200	
76.11342	HEU			HEU			0.29972	
77.32542	Lead			Lead			1.21200	
78.53742	Lead			Lead			1.21200	
78.83714	HEU			HEU			0.29972	
80.04914	Lead			Lead			1.21200	
81.26114	Lead			Lead			1.21200	
81.56086	HEU			HEU			0.29972	
83.05946	NU			NU			1.49860	
97.48666	Lower Ref.						14.42720	
103.83666	Platen+PAP						6.35000

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Duplicated the stacking, thicknesses of Pb plates, presence of NU and other plates from the JAEA representation.

Used JENDL4.0 cross sections for calculations.

Composition of Pb is unknown. Three runs were made: one with normally diluted (Pb - 7.8 at% Al mixture), one with Pb-0.2 at% Al (which represents 0.012cm Al on 1.2cm of Pb) the other 100% Pb.

Results:

Pb:7.8 Al	1.01507
Pb:0.2 Al	1.00855
Pb	1.00894
JAEA	1.00643

Conclusion: JAEA results are outside of bounds these calculations.

Are there other variations in material composition or density (Pb, Cu)?

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Further calculations were performed with lower values for density of Pb/Al.

$\text{Rho} = 8.4 \text{ g/cm}^3$ is a good fit for the base case (actual den = 9.016).

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But reactivity change from voided Pb regions still does not match JAEA results?

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Conclusions:

LANL calculations tend to support Pb void worth of $-3.40\text{E-}03$ to $-3.80\text{E-}03$ when all Pb plates are removed (6V).

JAEA calculations reported show void worth of $-2.56\text{E-}03$ to $-3.25\text{E-}03$ depending on choice of libraries.

LANL simulations expect base $k_{\text{eff}} = 1.0131(1)$ to $1.0186(1)$ while JAEA results are between $1.00643(5)$ to $1.02811(5)$.

It is still not clear why such large discrepancies still exists although it seems likely the models are different in a fundamental way.

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ZHEU16_AI -Pb-homog_r1.txt

Zeus Experiment 14 HEU Plates 14 NatU Plates 14 Lead Plates (2x1.2cm)

```

c
c - subdivide interior Pb more to reflect JAEA voiding cases
c
c - start with ZeusHEU1 from Joetta (10/16/2014):
c   - ack1 deck mods:
c     - upgrade .62c & .66c cross sections to ;
c     - upgrade elemental Mg, S, Ti and Mo to isotopic.
c     - include 204Pb and recalculate weight fractions in m7;
c     - change "kcode 10000 1.0 50 150" to "kcode 10000 1.0 50 5050".
c - start with ZeusHEU9 from Skip (10/23/2014):
c   - jmg deck mods:
c     - added additional lead unit below membrane
c     - removed one lead unit from top
c     - change lead thickness 2x1.1 cm -> 2x1.2 cm
c     - add uranium to top disk
c
c Comet Hardware
1 2 0.059114 13 -16 18 -19 $ Platen & Adapter
2 2 0.059114 9 -10 -42 65 $ Alignment Tube
3 1 0.085376 2 -3 6 -7 42 -43 $ Diaphragm
c Side Reflectors
4 3 0.082784 1 -3 5 -6 66 -67 $ Front, 1st Layer
5 3 0.082784 1 -2 6 -8 66 -67 $ Left, 1st Layer
6 3 0.082784 2 -4 7 -8 66 -67 $ Back, 1st Layer
7 3 0.082784 3 -4 5 -7 66 -67 $ Right, 1st Layer
c Corner Reflectors
8 3 0.082953 2 -3 6 -7 17 -42 66 $ Below Diaphragm
9 3 0.082953 2 -3 6 -7 17 43 -63 $ Above Diaphragm
10 3 0.083394 2 -3 6 -7 63 -69 $ Top Reflector
c Column of Platters
11 3 0.083315 11 -16 19 -20 $ Bottom Reflector
12 4 0.048620 (21 -22 12 -15) $ HEU Disks
13 4 0.048620 (24 -25 12 -15)
14 4 0.048620 (27 -28 12 -15)
15 4 0.048620 (30 -31 12 -15)
16 4 0.048620 (33 -34 12 -15)
17 4 0.048620 (36 -37 12 -15)
18 4 0.048620 (39 -40 12 -15)
19 4 0.048620 (43 -44 -15)
20 4 0.048620 (46 -47 -15)
21 4 0.048620 (49 -50 -15)
22 4 0.048620 (52 -53 -15)
23 4 0.048620 (55 -56 -15)
24 4 0.048620 (58 -59 -15)
25 4 0.048620 (61 -62 -15 70)
126 4 0.048620 (62 -163 -15 64)
26 5 0.047810 (21 -22 15 -16) $ Outer Rings
27 5 0.047810 (24 -25 15 -16)
28 5 0.047810 (27 -28 15 -16)
29 5 0.047810 (30 -31 15 -16)
30 5 0.047810 (33 -34 15 -16)
31 5 0.047810 (36 -37 15 -16)
32 5 0.047810 (39 -40 15 -16)
33 5 0.047810 (43 -44 15 -16)
34 5 0.047810 (46 -47 15 -16)
35 5 0.047810 (49 -50 15 -16)
36 5 0.047810 (52 -53 15 -16)
37 5 0.047810 (55 -56 15 -16)
38 5 0.047810 (58 -59 15 -16)
39 5 0.047810 (61 -62 15 -16)
140 5 0.047810 (62 -163 15 -16)
40 9 -9.016 (20 -21 12 -16) $ Lead Disks

```

41 9 -9.016 (22 -24 12 -16)
 42 9 -9.016 (25 -27 12 -16)
 43 9 -9.016 (28 -30 12 -16)
 44 9 -9.016 (31 -33 70 -16)
 45 9 -9.016 (34 -36 70 -16)
 46 9 -9.016 (37 -39 70 -16)
 47 9 -9.016 (40 -42 70 -16)
 48 9 -9.016 (44 -46 -16)
 49 9 -9.016 (47 -49 -16)
 50 9 -9.016 (50 -52 -16)
 51 9 -9.016 (53 -55 -16)
 52 9 -9.016 (56 -58 -16)
 53 9 -9.016 (59 -61 -16)
 54 9 -9.016 (163 -63 -16)

c Internal Voids

55 0 10 -17 -18 66 \$ A-Tube - Refl Gap
 56 0 10 -13 18 -19 \$ A-Tube - Platen Gap
 57 0 -9 -42 66 \$ Inside Alignment Tube
 58 0 10 -11 19 -20 \$ A-tube - Platter Gap
 59 0 16 -17 18 -20 \$ Platter/Platen -Reflector Gap
 60 0 2 -3 6 -7 -67 69 \$ Above Top Reflector
 61 0 10 -12 20 -42 \$ Rings - A-tube Gap
 62 0 16 -17 20 -42 \$ Rings - Rfl Gap (Lwr)
 63 0 16 -17 43 -63 \$ Rings - Rfl Gap (Upr)
 64 0 61 -62 -70 \$ Inside HEU Disk
 164 0 62 -163 -64 \$ Inside HEU Disk
 65 9 -9.016 (31 -32 12 -70)
 66 9 -9.016 (32 -33 12 -70)
 67 9 -9.016 (34 -35 12 -70)
 68 9 -9.016 (35 -36 12 -70)
 69 9 -9.016 (37 -38 12 -70)
 70 9 -9.016 (38 -39 12 -70)
 71 9 -9.016 (40 -41 12 -70)
 72 9 -9.016 (41 -42 12 -70)

c External Voids

168 0 -1 \$ Left of Side Rfl s
 169 0 4 \$ Right of Side Rfl s
 170 0 1 -4 -5 \$ Front of Side Rfl s
 171 0 1 -4 8 \$ Behind Side Rfl s
 172 0 1 -4 5 -8 67 \$ Above Reflectors
 173 0 1 -4 5 -8 -66 #2 #55 \$ Below Reflectors

1 px -44.14520 \$ Left Rfl Edge
 2 px -27.94000 \$ Left Int Rfl Edge
 3 px 27.94000 \$ Right Int Rfl Edge
 4 px 44.14520 \$ Right Rfl Edge
 5 py -44.14520 \$ Front Rfl Edge
 6 py -27.94000 \$ Front Int Rfl Edge
 7 py 27.94000 \$ Back Int Rfl Edge
 8 py 44.14520 \$ Back Rfl Edge
 9 cz 2.5400 \$ 1.0-in Radius
 10 cz 3.1496 \$ 1.24-in. Radius
 11 cz 3.1750 \$ 1.25-in. Radius
 12 cz 3.18770 \$ 1.255-in. Radius
 13 cz 4.7625 \$ 1.875-in. Radius
 14 cz 7.62635 \$ 3.0025-in. Radius
 15 cz 19.0500 \$ Disk Outer Radius
 16 cz 26.6700 \$ Platter OR
 17 cz 26.7970 \$ Corner Rfl IR

c column, bottom to top

18 pz 16.8336 \$ Bottom of Platen Spt
 19 pz 23.1836 \$ Top of Platen
 20 pz 37.6108 \$ Top of Column Reflector(penny)

ZHEU16_AI -Pb-homog_r1. txt

21 pz 38.8108 \$ NatU Di sk 1 wi th Wi de Hol e
 22 pz 39.1105 \$ HEU Di sk and Ri ng 1
 23 pz 40.3105 \$ Lead Di sk 1
 24 pz 41.5105 \$ Lead Di sk 1
 25 pz 41.8102 \$ HEU Di sk and Ri ng 2
 26 pz 43.0102 \$ Lead Di sk 2
 27 pz 44.2102 \$ Lead Di sk 2
 28 pz 44.5099 \$ HEU Di sk and Ri ng 3
 29 pz 45.7099 \$ Lead Di sk 3
 30 pz 46.9099 \$ Lead Di sk 3
 31 pz 47.2096 \$ HEU Di sk and Ri ng 4
 32 pz 48.4096 \$ Lead Di sk 4
 33 pz 49.6096 \$ Lead Di sk 4
 34 pz 49.9094 \$ HEU Di sk and Ri ng 5
 35 pz 51.1094 \$ Lead Di sk 5
 36 pz 52.3094 \$ Lead Di sk 5
 37 pz 52.6091 \$ HEU Di sk and Ri ng 6
 38 pz 53.8091 \$ Lead Di sk 6
 39 pz 55.0091 \$ Lead Di sk 6
 40 pz 55.3088 \$ HEU Di sk and Ri ng 7
 41 pz 56.5088 \$ Lead Di sk 7
 42 pz 57.7088 \$ Lead Di sk 7
 43 pz 57.97296 \$ Di a phragm
 44 pz 58.2727 \$ HEU Di sk and Ri ng 1
 45 pz 59.4727 \$ Lead Di sk 1
 46 pz 60.6727 \$ Lead Di sk 1
 47 pz 60.9724 \$ HEU Di sk and Ri ng 2
 48 pz 62.1724 \$ Lead Di sk 2
 49 pz 63.3724 \$ Lead Di sk 2
 50 pz 63.67212 \$ HEU Di sk and Ri ng 3
 51 pz 64.87212 \$ Lead Di sk 3
 52 pz 66.07212 \$ Lead Di sk 3
 53 pz 66.37184 \$ HEU Di sk and Ri ng 4
 54 pz 67.57184 \$ Lead Di sk 4
 55 pz 68.77184 \$ Lead Di sk 4
 56 pz 69.07156 \$ HEU Di sk and Ri ng 5
 57 pz 70.27156 \$ Lead Di sk 5
 58 pz 71.47156 \$ Lead Di sk 5
 59 pz 71.77128 \$ HEU Di sk and Ri ng 6
 60 pz 72.97128 \$ Lead Di sk 6
 61 pz 74.17128 \$ Lead Di sk 6
 62 pz 74.471 \$ HEU Ri ng 7
 163 pz 74.7707 \$ HEU Ri ng 8
 63 pz 75.971 \$ Lead Di sk 7
 64 cz 7.62 \$ 6-i n Radi us
 c support structure
 65 pz -5.79120 \$ Bottom of Al ignment Tube
 66 pz 0.0 \$ Bottom of Refl ectors
 c side reflectors
 67 pz 103.25100 \$ Top of Si de Refl ectors
 c corner and top reflectors
 68 pz 75.471 \$ Top of Corner Refl ectors and Lead Di sk 7
 69 pz 89.0979 \$ Top Refl ector
 70 cz 12.7 \$ Lead/Voi d cyl inder surface (5-i n Radi us)

mode n

kcode 5000 1.0 100 10100

rand hist=14285714

imp:n 1.0 74r 0.0 5r

ksrc 0.0 -15.0 41.46062 0.0 15.0 41.46062
 0.0 -15.0 43.96034 0.0 15.0 43.96034
 0.0 -15.0 46.46006 0.0 15.0 46.46006
 0.0 -15.0 48.95978 0.0 15.0 48.95978

ZHEU16_Al -Pb-homog_r1. txt

0.0 -15.0 51.4595 0.0 15.0 51.4595
0.0 -15.0 53.95922 0.0 15.0 53.95922
0.0 -15.0 56.45894 0.0 15.0 56.45894
0.0 -15.0 58.82268 0.0 15.0 58.82268
0.0 -15.0 61.3224 0.0 15.0 61.3224
0.0 -15.0 63.82212 0.0 15.0 63.82212
0.0 -15.0 66.32184 0.0 15.0 66.32184
0.0 -15.0 68.82156 0.0 15.0 68.82156
0.0 -15.0 71.32128 0.0 15.0 71.32128
0.0 -15.0 73.821 0.0 15.0 73.821
c SS 304
m1 6000 2.0637e-4
7014 1.6966e-4 7015 6.3007e-7
14028 9.3687e-4 14029 4.7438e-5
14030 3.1490e-5
15031 4.2278e-5
c 16000.62c 5.8332e-6
16032 5.53746e-6 16033 4.43323e-8 16034 2.50244e-7
16036 1.16664e-9
24050 7.1440e-4 24052 1.3777e-2
24053 1.5620e-3 24054 3.8885e-4
25055 1.4557e-3
26054 3.5137e-3 26056 5.4623e-2
26057 1.2506e-3 26058 1.6675e-4
28058 4.4066e-3 28060 1.6847e-3
28061 7.2937e-5 28062 2.3172e-4
28064 5.8737e-5
29063 1.0690e-5 29065 4.7648e-6
c 42000.66c 1.3649e-5
42092 2.02551e-6 42094 1.26253e-6 42095 2.17292e-6
42096 2.27665e-6 42097 1.30348e-6 42098 3.29350e-6
42100 1.31440e-6
c Al umi num 6061 (2.70 g/cc)
c m2 12000.62c 6.6049e-4
m2 12024 5.21721e-4 12025 6.60490e-5 12026 7.27199e-5
13027 5.7816e-2
14028 3.1630e-4 14029 1.6016e-5
14030 1.0631e-5
c 22000.62c 2.5146e-5
22046 2.07455e-6 22047 1.87086e-6 22048 1.85376e-5
22049 1.36040e-6 22050 1.30256e-6
24050 3.3536e-6 24052 6.4673e-5
24053 7.3325e-6 24054 1.8254e-6
25055 2.1915e-5
26054 5.9360e-6 26056 9.2280e-5
26057 2.1128e-6 26058 2.8171e-7
29063 4.8053e-5 29065 2.1418e-5
c Copper (8.7447 g/cc)
m3 29063 5.7322e-2 29065 2.5549e-2
c Average Pure Inner Fuel Di sks (93.28 wt.% enriched)
m4 92234 5.0377e-4 92235 4.5384e-2
92236 1.1337e-4 92238 2.6211e-3
c Average Pure Outer Fuel Ri ngs (93.17 wt.% enriched)
m5 92234 4.8707e-4 92235 4.4574e-2
92236 2.0675e-4 92238 2.5424e-3
c Natural Urani um
m6 92234 2.6518e-6 92235 3.4701e-4
92238 4.7846e-2
c Lead
c m7 82206 -.23949
c 82207 -.23446
c 82208 -.52577
m7 82204 -0.013780838

ZHEU16_AI -Pb-homog_r1. txt

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82206 -0. 239554999
82207 -0. 220742958
82208 -0. 525921205
c Al umi num 6061 (2. 70 g/cc)
m8 13027 6. 6049e-4
c Al -Pb homogeni zed, den=10. 60 g/cc
m9 82204 -0. 012694
82206 -0. 22066
82207 -0. 20334
82208 -0. 48445
13027 -0. 0788861

totnu
print
kopts blocksize = 5
ksen1 xs rxn = -1 -2 +2 +4 -6 -7
ksen2 xs iso = 82204 82206 82207 82208
      rxn = -1 -2 +2 +4
erg =0. 0000E+00 3. 2242E-07 4. 1399E-07 5. 3158E-07 6. 8256E-07 8. 7642E-7
1. 1254E-06 1. 4450E-06 1. 8554E-06 2. 3824E-06 3. 0590E-06 3. 9279E-06
5. 0435E-06 6. 4760E-06 8. 3153E-06 1. 0677E-05 1. 3710E-05 1. 7603E-05
2. 2603E-05 2. 9023E-05 3. 7267E-05 4. 7851E-05 6. 1442E-05 7. 8893E-05
1. 0130E-04 1. 3007E-04 1. 6702E-04 2. 1445E-04 2. 7536E-04 3. 5358E-04
4. 5400E-04 5. 8295E-04 7. 4852E-04 9. 6112E-04 1. 2341E-03 1. 5846E-03
2. 0347E-03 2. 6126E-03 3. 3546E-03 4. 3074E-03 5. 5308E-03 7. 1017E-03
9. 1188E-03 1. 1709E-02 1. 5034E-02 1. 9305E-02 2. 4788E-02 3. 1828E-02
4. 0868E-02 5. 2475E-02 6. 7379E-02 8. 6517E-02 1. 1109E-01 1. 4264E-01
1. 8316E-01 2. 3518E-01 3. 0197E-01 3. 8774E-01 4. 9787E-01 6. 3928E-01
8. 2085E-01 1. 0540E+00 1. 3534E+00 1. 7377E+00 2. 2313E+00 2. 8650E+00
3. 6788E+00 4. 7237E+00 6. 0653E+00 7. 7880E+00 1. 0000E+01

ksen3 xs cell=(66 67 68 69 70 71) (45 46 47)
      iso = 82204 82206 82207 82208
      rxn = -1 -2 +2 +4
erg =0. 0000E+00 3. 2242E-07 4. 1399E-07 5. 3158E-07 6. 8256E-07 8. 7642E-7
1. 1254E-06 1. 4450E-06 1. 8554E-06 2. 3824E-06 3. 0590E-06 3. 9279E-06
5. 0435E-06 6. 4760E-06 8. 3153E-06 1. 0677E-05 1. 3710E-05 1. 7603E-05
2. 2603E-05 2. 9023E-05 3. 7267E-05 4. 7851E-05 6. 1442E-05 7. 8893E-05
1. 0130E-04 1. 3007E-04 1. 6702E-04 2. 1445E-04 2. 7536E-04 3. 5358E-04
4. 5400E-04 5. 8295E-04 7. 4852E-04 9. 6112E-04 1. 2341E-03 1. 5846E-03
2. 0347E-03 2. 6126E-03 3. 3546E-03 4. 3074E-03 5. 5308E-03 7. 1017E-03
9. 1188E-03 1. 1709E-02 1. 5034E-02 1. 9305E-02 2. 4788E-02 3. 1828E-02
4. 0868E-02 5. 2475E-02 6. 7379E-02 8. 6517E-02 1. 1109E-01 1. 4264E-01
1. 8316E-01 2. 3518E-01 3. 0197E-01 3. 8774E-01 4. 9787E-01 6. 3928E-01
8. 2085E-01 1. 0540E+00 1. 3534E+00 1. 7377E+00 2. 2313E+00 2. 8650E+00
3. 6788E+00 4. 7237E+00 6. 0653E+00 7. 7880E+00 1. 0000E+01

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