LA-UR-15-24974

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Title: Zeus Approach to Critical Process with Calculated Multiplication and Dimensions and Mass of Available Parts

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Intended for: Transmission to JAEA Collaborators

Issued: 2015-07-02

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Zeus Approach to Critical Process
with Calculated Multiplication
and
Dimensions and Mass of Available Parts

Joetta Goda, Theresa Cutler

LANL

Load 1 unit

Raise unit into reflector

This is done using the local control station that is in the room with Comet.

Take a neutron count while fully closed

Load 2nd unit

Not to Scale

Raise unit into reflector

Take a neutron count while
fully closed

Predict Critical

	keff	M	1/M	normalized	slope	y-int	Predicted Crit	3/4 PC	1/2 rule
1	0.2644	1.359434	0.7356	1.00					
2	0.4078	1.688619	0.5922	0.81	-0.19	1.19	6.13	4.60	4.06

- Plot the inverse multiplication of both points normalized to the first point.
- Predicted critical is at x-intercept. Above 6 units in this case.
- For the calculations we used the multiplication from the calculation instead of count rate as will be used during the experiment.

Determine next addition

- Handstack Administrative Limits are:

- $\frac{3}{4}$ of Predict Critical Mass
($k_{\text{eff}} \sim .90$) = 4.6 units

OR

- $\frac{1}{2}$ way from where stack currently is to predicted critical = 4.06 units

- So adding a 3rd unit is allowed.

Continue

- Add additional unit.
- Raise into reflector.
- Take count rate.

	keff	M	1/M	normalized	slope	y-int	Predicted Crit	3/4 PC	1/2 rule
1	0.2644	1.359434	0.7356	1.00					
2	0.4078	1.688619	0.5922	0.81	-0.19	1.19	6.13	4.60	4.06
3	0.5165	2.068252	0.4835	0.66	-0.15	1.10	7.45	5.59	5.22
4	0.6029	2.518257	0.3971	0.54	-0.12	1.01	8.60	6.45	6.30
5	0.6738	3.065604	0.3262	0.44	-0.10	0.93	9.60	7.20	7.30
6	0.7335	3.752345	0.2665	0.36	-0.08	0.85	10.46	7.85	8.23
7	0.7848	4.64684	0.2152	0.29	-0.07	0.78	11.19	8.40	9.10

- Repeat.
- We predict that we can continue to desired total of 7 units while operating locally.

7 Units

Install 7 units in Upper Reflector

Not to Scale

- The 7 units are removed from the bottom.
- 7 units are added to the top using the solid pieces instead of the 2.5" ID pieces.
- The total additional mass is ~200 g, equivalent to .02 units.
- The lower reflector is raised and count rate taken.

Renormalize

- Count rate is used as the new normalization.
- Additional units are again added to the bottom stack.
- According to calculations, we can add up to the 10th unit locally, but we will use the actual count rates during the experiment to decide.

	keff	M	1/M	normalized	slope	y-int	Predicted Crit	3/4 PC	1/2 rule
7	0.7944	4.863813	0.2056	1.00					
8	0.8367	6.123699	0.1633	0.79	-0.21	2.65	12.86	9.65	10.93
9	0.8732	7.886435	0.1268	0.62	-0.18	2.39	13.47	10.11	11.74
10	0.9063	10.67236	0.0937	0.46	-0.16	2.23	13.83	10.37	12.42
11	0.9354	15.47988	0.0646	0.31	-0.14	2.01	14.22	10.66	13.11
12	0.9615	25.97403	0.0385	0.19	-0.13	1.84	14.48	10.86	13.74
13	0.9854	68.49315	0.0146	0.07	-0.12	1.70	14.61	10.96	14.31

- After the 11th unit is added, we will be required to operate from the Control Room (remotely) to raise the lower stack into the reflector.

Critical

- We predict 14 units will go above critical.
- We will insert an Al spacer(not the same spacer as for the lead voids) when we first close on 14 units.
- Take count rate.
- Replace with a thinner spacer.
- Take count rate.
- Estimate excess reactivity.
- Remove spacer if possible.
- Our excess reactivity limit is 80 cents (~520 pcm).

Summary of Calculated 1/M Data

	keff	M	1/M	normalized	slope	y-int	Predicted Crit	3/4 PC	1/2 rule
1	0.2644	1.359434	0.7356	1.00					
2	0.4078	1.688619	0.5922	0.81	-0.19	1.19	6.13	4.60	4.06
3	0.5165	2.068252	0.4835	0.66	-0.15	1.10	7.45	5.59	5.22
4	0.6029	2.518257	0.3971	0.54	-0.12	1.01	8.60	6.45	6.30
5	0.6738	3.065604	0.3262	0.44	-0.10	0.93	9.60	7.20	7.30
6	0.7335	3.752345	0.2665	0.36	-0.08	0.85	10.46	7.85	8.23
7	0.7848	4.64684	0.2152	0.29	-0.07	0.78	11.19	8.40	9.10
7	0.7944	4.863813	0.2056	1.00					
8	0.8367	6.123699	0.1633	0.79	-0.21	2.65	12.86	9.65	10.93
9	0.8732	7.886435	0.1268	0.62	-0.18	2.39	13.47	10.11	11.74
10	0.9063	10.67236	0.0937	0.46	-0.16	2.23	13.83	10.37	12.42
11	0.9354	15.47988	0.0646	0.31	-0.14	2.01	14.22	10.66	13.11
12	0.9615	25.97403	0.0385	0.19	-0.13	1.84	14.48	10.86	13.74
13	0.9854	68.49315	0.0146	0.07	-0.12	1.70	14.61	10.96	14.31
14	Above 1.0

Dimensions and Mass of Available Parts

Lead Order #1

Item		OD (in)	ID(in) nominal	Thickness (in)	Mass (g)
128Y1720391-01	1	2.4880	0	0.2555	181.8
2.5"	2	2.4845	0	0.2550	181.2
	3	2.4930	0	0.2575	182.5
	4	2.4835	0	0.2560	181.5
	5	2.4865	0	0.2550	181.7
	6	2.4895	0	0.2600	182.0
	7	2.4855	0	0.2635	181.1
	8	2.4880	0	0.2535	182.4
	9	2.4860	0	0.2615	181.9
	10	2.4850	0	0.2625	180.8
	11	2.4850	0	0.2560	181.5
	12	2.4875	0	0.2520	181.4
128Y1720391-03	1	14.969	0	0.2954	7126.6
15"	2	14.994	0	0.2720	7180.6
	3	14.998	0	0.2770	6739.9
	4	14.960	0	0.2865	7152.4
	5	14.955	0	0.2759	7146.1
	6	14.995	0	0.2725	7207.3
	7	14.990	0	0.2585	6750.5
	8	14.995	0	0.2700	6737.4
	9	14.997	0	0.2695	6767.3
	10	14.996	0	0.2690	6730.2
	11	14.978	0	0.2605	6752.1
	12	14.999	0	0.2675	6731.0
	13	14.988	0	0.2605	6752.9
	14	14.988	0	0.2580	6768.3
	15	14.988	0	0.2620	6699.7
	16	14.990	0	0.2615	6706.8
	17	14.989	0	0.2565	6724.6
	18	14.990	0	0.2570	6725.6
	19	14.992	0	0.2585	6735.1
	20	14.994	0	0.2560	6730.5

Item		OD (in)	ID(in) nominal	Thickness (in)	Mass (g)
6"/2.5"	1	5.987	2.5	0.2630	872.4
	2	5.989	2.5	0.2530	869.4
	3	5.985	2.5	0.2520	871.4
	4	5.993	2.5	0.2565	878.2
	5	5.992	2.5	0.2515	867.1
128Y1720392-03	1	9.995	2.5	0.2580	2761.2
10"/2.5"	2	9.996	2.5	0.2550	2706.4
	3	9.995	2.5	0.2610	2750.1
	4	9.994	2.5	0.2515	2737.4
	5	9.995	2.5	0.2530	2742.9
	6	9.999	2.5	0.2525	2774.9
128Y1720392-05	1	14.992	2.5	0.2725	2952.9
15"/2.5"	2	14.994	2.5	0.3145	6992.0
	3	14.993	2.5	0.2720	7003.8
	4	14.986	2.5	0.2830	6962.2
	5	14.990	2.5	0.2795	6917.5
	6	14.995	2.5	0.2780	6924.8
	7	14.995	2.5	0.2820	6970.5
	8	14.965	2.5	0.2875	6970.5
	9	14.994	2.5	0.2895	6975.8
	10	14.997	2.5	0.2890	6992.6
	11	14.994	2.5	0.2810	6937.6
	12	14.998	2.5	0.2815	7010.6
	13	14.990	2.5	2.2735	6952.2
	14	14.985	2.5	0.2715	6943.5
	15	14.998	2.5	0.2930	7009.4
	16	14.999	2.5	0.2830	9673.0
	17	14.199	2.5	0.2665	6925.0
	18	14.993	2.5	0.2650	6934.0
	19	14.998	2.5	0.2880	6996.8
	20	14.984	2.5	0.2820	6998.9

Lead Order # 1 (cont)

Item		OD (in)	ID(in) nominal	Thickness (in)	Mass (g)
128Y172039					
2-07	1	21	15	0.2505	6121.5
21"/15"	2	21	15	0.2495	6121.0
	3	21	15	0.2505	6118.1
	4	21	15	0.2505	6142.0
	5	21	15	0.2575	6240.5
	6	21	15	0.2515	6316.2
	7	21	15	0.2515	6334.6
	8	21	15	0.2550	6219.9
	9	21	15	0.2525	6187.1
	10	21	15	0.2520	6336.2
	11	21	15	0.2550	6194.5
	12	21	15	0.2550	6204.5
	13	21	15	0.2595	6339.6
	14	21	15	0.2485	6220.4
	15	21	15	0.2635	6342.4
	16	21	15	0.2520	6311.7
	17	21	15	0.2595	6409.9
	18	21	15	0.2895	6303.1
	19	21	15	0.2550	6385.6
	20	21	15	0.2670	6404.2
	21	21	15	0.2735	6379.0
	22	21	15	0.2570	6348.3
	23	21	15	0.2550	6335.1
	24	21	15	0.2575	6330.2
	25	21	15	0.2480	6010.5
	26	21	15	0.2510	5980.5
	27	21	15	0.2560	6411.9
	28	21	15	0.2570	6376.7
	29	21	15	0.2580	6322.2
	30	21	15	0.2580	6331.8
	31	21	15	0.2580	6347.8
	32	21	15	0.2540	6314.3
	33	21	15	0.2625	6366.2
	34	21	15	0.2620	6330.2
	35	21	15	0.2525	6351.4
	36	21	15	0.2585	6362.6
	37	21	15	0.2520	6338.0
	38	21	15	0.2600	6276.7
	39	21	15	0.2547	6348.9
	40	21	15	0.2560	6284.1

Lead Order #2

	Part	OD(in)	ID(in) nominal	Thickness (in)	weight(g)
128Y1720391-03	1	14.98	0	0.25	6556.1
15" plates	2	14.98	0	0.25	6578.3
	3	14.98	0	0.25	6518.6
	4	14.97	0	0.25	6513.8
	5	14.98	0	0.25	6579.3
	6	14.97	0	0.25	6514.7
	7	14.98	0	0.25	6525.3
	8	14.98	0	0.24	6519.0
	9	14.99	0	0.25	6498.9
	10	14.99	0	0.25	6522.3
	11	14.99	0	0.25	6505.4
	12	14.98	0	0.25	6514.2
	13	14.98	0	0.25	6502.3
	14	14.98	0	0.25	6519.0
	15	14.98	0	0.25	6540.2
	16	14.98	0	0.25	6568.7
128Y1720392-03	1	9.97	2.5	0.25	2730.7
10"/2.5"	2	9.98	2.5	0.25	2714.8
	3	9.98	2.5	0.25	2722.5
	4	9.98	2.5	0.26	2725.9
	5	9.98	2.5	0.25	2722.0
	6	9.98	2.5	0.25	2730.2
	7	9.99	2.5	0.25	2736.1
	8	9.98	2.5	0.25	2712.8
	9	9.98	2.5	0.25	2714.3
	10	9.98	2.5	0.25	2713.7

	Part	OD(in)	ID(in) nominal	Thickness (in)	weight(g)
128Y1720392-07	1	21	15	0.25	6265.4
21"/15"	2	21	15	0.25	6298.2
	3	21	15	0.26	6252.0
	4	21	15	0.25	6266.4
	5	21	15	0.25	6268.6
	6	21	15	0.25	6224.8
	7	21	15	0.25	6258.6
	8	21	15	0.25	6271.3
	9	21	15	0.25	6254.6
	10	21	15	0.25	6237.9
	11	21	15	0.25	6271.5
	12	21	15	0.26	6271.0
	13	21	15	0.26	6307.8
	14	21	15	0.26	6294.7
	15	21	15	0.26	6290.0
	16	21	15	0.26	6289.0
	17	21	15	0.26	6265.3
	18	21	15	0.26	6285.4
	19	21	15	0.25	6255.9
	20	21	15	0.26	6260.5
128Y1720392-09	1	14.98	10	0.24	3646.1
15"/2.5"	2	14.97	10	0.24	3592.2
	3	14.98	10	0.25	3649.4
	4	14.98	10	0.24	3602.6
	5	14.98	10	0.25	3643.7
	6	14.97	10	0.25	3604.2
	7	14.97	10	0.25	3617.5
	8	14.98	10	0.25	3609.0
	9	14.97	10	0.26	3633.9
	10	14.98	10	0.25	3640.2
	11	14.98	10	0.26	3609.7
	12	14.98	10	0.25	3613.6
	13	14.98	10	0.25	3616.4
	14	14.98	10	0.25	3643.2
	15	14.98	10	0.25	3620.1
	16	14.98	10	0.25	3609.9

Al spacers

	Part	OD(in)	ID(in) nominal	Thickness	weight(g)
128Y-271100-D10-B	1	5.98	2.5	0.47	485.3
	2	5.98	2.5	0.47	484.9
	3	5.99	2.5	0.47	485.8
	4	5.98	2.5	0.47	486.0
	5	5.98	2.5	0.48	486.3
	6	5.95	2.5	0.48	485.9
128Y-271100-D1-A	1	15	2.5		618.9
	2	15	2.5		619.0
	3	15	2.5		619.3
	4	15	2.5		619.7
	5	15	2.5		618.0
	6	15	2.5		618.3
	7	15	2.5		618.5
	8	15	2.5		620.9
	9	15	2.5		631.8
	10	15	2.5		627.7
	11	15	2.5		626.8
	12	15	2.5		613.3

Order of new Spacers has not arrived, so weights are not available yet. We will send separately.

HEU

	Part #	OD (in)	ID (in)	Mass (g)	Quantity
10 " hole	B1010481	15	10	3595	8
	B1010483	15	10	3542	
	B1010458	15	10	3619	
	B1010485	15	10	3609	
	B1010479	15	10	3565	
	B1010473	15	10	3609	
	B1010463	15	10	3632	
	B1010472	15	10	3592	
6" hole	B1010477	15	6	5502	7
	B1010457	15	6	5575	
	B1010935	15	6	5442	
	B1011018	15	6	5378	
	B1010932	15	6	5440	
	10493	15	6	5441	
	10933	15	6	5442	
2.5" hole	10487	15	2.5	6277	7
	B1010470	15	2.5	6291	
	B1010491	15	2.5	6396	
	B1010467	15	2.5	6337	
	B1010475	15	2.5	6244	
	B1010489	15	2.5	6350	
	10464	15	2.5	6259	
15" solid	11149	15	0	6412	5
	11017	15	0	6518	
	11019	15	0	6477	
	11147	15	0	6539	
	11150	15	0	6441	

	Part #	OD (in)	ID (in)	Mass (g)	Quantity
wedges	8601			1072	6
	8602			1076	
	8603			1065	
	8604			1074	
	8605			1073	
	8606			1086	
6" solid	Q2-16	6	0		
rings	B-2444-01	21	15	6144	25
	B-2444-02	21	15	6140	
	B-2444-03	21	15	6124	
	B-2444-04	21	15	6122	
	B-2444-07	21	15	6134	
	B-2444-09	21	15	6081	
	B-2444-10	21	15	6157	
	B-2444-11	21	15	6137	
	B-2444-13	21	15	6043	
	B-2444-14	21	15	6147	
	B-2444-17	21	15	6158	
	B-2444-18	21	15	6159	
	B-2444-19	21	15	6142	
	B-2444-20	21	15	6179	
	B-2444-22	21	15	6035	
	B-2444-24	21	15	6105	
	B-2444-25	21	15	6110	
	B-2444-27	21	15	6084	
	B-2444-28	21	15	6125	
	B-2444-29	21	15	6145	
	B-2444-31	21	15	6197	
	B-2444-33	21	15	6184	
	B-2444-35	21	15	6146	
	B-2444-36	21	15	6152	
	B-2444-37	21	15	6150	