ANL Critical Assembly Covariance Matrix Generation - Addendum

Nuclear Engineering Division

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November, 2012

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In March 2012, a report was issued on covariance matrices for Argonne National Laboratory (ANL) critical experiments. That report detailed the theory behind the calculation of covariance matrices and the methodology used to determine the matrices for a set of 33 ANL experimental set-ups. Since that time, three new experiments have been evaluated and approved. This report essentially updates the previous report by adding in these new experiments to the preceding covariance matrix structure.

Shown in Table 1 are the 36 assemblies included in this new covariance tabulation, with the new assemblies printed in red.

Table 1. ANL Benchmark Evaluations used to develop the ANL Correlation Matrices.

ICSBEP ID Name	Configuration
ZPR-3	
IEU-MET-FAST-015	ASSEMBLY 6F
IEU-MET-FAST-016	ASSEMBLY 11
IEU-COMP-FAST-004	ASSEMBLY 12
HEU-MET-FAST-055	ASSEMBLY 23
IEU-MET-FAST-012	ASSEMBLY 41
MIX-COMP-FAST-003	ASSEMBLY 48
MIX-COMP-FAST-003	ASSEMBLY 48B
MIX-COMP-FAST-004	ASSEMBLY 56B
ZPR-6	
IEU-COMP-INTER-005	ASSEMBLY 6A
MIX-COMP-FAST-001	ASSEMBLY 7
MIX-COMP-FAST-002	ASSEMBLY 7 HIGH 240PU CORE
PU-MET-INTER-002	ASSEMBLY 10
ZPR-9	
IEU-MET-FAST-013	ASSEMBLY 1
IEU-MET-FAST-014	ASSEMBLY 2
IEU-MET-FAST-014	ASSEMBLY 3
HEU-MET-FAST-060	ASSEMBLY 4
HEU-MET-FAST-067	ASSEMBLY 5
HEU-MET-FAST-067	ASSEMBLY 6
HEU-MET-FAST-070	ASSEMBLY 7
HEU-MET-FAST-070	ASSEMBLY 8
HEU-MET-FAST-070	ASSEMBLY 9
MIX-COMP-FAST-005	ASSEMBLY 31
IEU-MET-FAST-010	ASSEMBLY 34 (U9 BENCHMARK) L11
HEU-MET-INTER-001	ASSEMBLY 34 (URANIUM/IRON BENCHMARK) L303

ZPPR-2	
MIX-COMP-FAST-006	ZPPR-2 Loading 90
ZPPR-12	
ZPPR-LMFBR-EXP-010	ZPPR-12 Loading 9
ZPPR-20	
HEU-MET-FAST-075	PHASE C
HEU-MET-MIXED-012	PHASE D
SUB-HEU-MET-MIXED-001	PHASE D subcritical
SUB-HEU-MET-FAST-001	PHASE E subcritical
ZPPR-21	
PU-MET-FAST-033	PHASE A
MIX-MET-FAST-011	PHASE B
MIX-MET-FAST-011	PHASE C
MIX-MET-FAST-011	PHASE D
MIX-MET-FAST-011	PHASE E
HEU-MET-FAST-061	PHASE F

These new experiments (ZPR-9 Assembly 31, ZPPR-2 and ZPPR-12), all plutonium based, achieved criticality on November 30, 1976, October 9, 1970, and December 17, 1981, respectively.

For each configuration in Table 1, a summary of the reactivity uncertainties was included as a specific table in the benchmark document. Shown in Tables 2-4 are the detailed uncertainty values directly from the three new benchmark reports. The entries for these three new configurations include a "subtotal" component which is the quadrature sum of the individual components within a specific "Source of Uncertainty". The uncertainty tables for the remaining 33 assemblies are included in Appendix B of the original report.

Table 2. Uncertainties for ZPR-9 Assembly 31 (MIX-COMP-FAST-005).

ZPR-9 Assembly 31: A CYLINDRICAL ASSEMBLY WITH MIXED (PU,U)-CARBIDE FUEL AND DEPLETED URANIUM CARBIDE BLANKET		
Source of Uncertainty	Uncertainty Type	Uncertainty in Excess Reactivity $\% \Delta k$
Measurement Technique		
	Experimentalists' Estimate	0.0005
	Reproducibility	0.0033
	In hours to Δk conversion	0.0026
	Subtotal	0.0042
Geometry		
	Nominal Plate Dimensions	0.0080
	Matrix Tube Pitch	0.0517
	Subtotal	0.0523
Composition		
	Plutonium	0.0472
	Uranium in Pu-U-Mo Plates	0.0129
	Molybdenum	0.0020
	Sodium	0.0013
	Graphite Plates	0.0011
	Depleted Uranium Plates	0.0854
	Steel in Reflector	0.0002
	Steel in the Matrix Tubes	0.0029
	Steel in the Drawers	0.0011
	Steel in the Cans	0.0012
	Humidity	0.0001
	Subtotal	0.0985
	Total	0.1116

Table 3. Uncertainties for ZPPR-2 Loading 90 (MIX-COMP-FAST-06).

ZPPR-2: A CYLINDRICAL ASSEMBLY WITH MIXED (PU,U)-OXIDE FUEL AND SODIUM REFLECTED BY DU, SODIUM, AND STEEL		
Source of Uncertainty	Uncertainty Type	Uncertainty in Excess Reactivity $\% \Delta k$
Measurement Technique		
	Experimentalists' Estimate	0.0010
	Temperature	0.0032
	Reproducibility	0.0030
	Inhours to Δk conversion	0.0032
	Subtotal	0.0055
Geometry		
	Nominal Plate Dimensions	0.0009
	Matrix Tube Pitch	0.0276
	Subtotal	0.0276
Composition		
	Plutonium	0.0446
	Uranium in Pu-U-Mo Plates	0.0135
	Molybdenum	0.0003
	Sodium	0.0013
	Sodium Carbonate Plates	0.0042
	Depleted Uranium Plates	0.0095
	Depleted U3O8 Plates	0.0339
	Iron Oxide Plates	0.0024
	Steel in Axial Blanket	0.0002
	Steel in the Matrix Tubes	0.0077
	Steel in the Drawers	0.0011
	Steel in the Cans	0.0028
	Humidity	0.0001
	Subtotal	0.0592
	Total	0.0655

Table 4. Uncertainties for ZPPR-12 Loading 9 (ZPPR-LMFBR-EXP-010 CRIT-REAC).

ZPPR-12: MOCKUP OF THE 400 MWe SODIUM-COOLED CLINCH RIVER BREEDER REACTOR		
Source of Uncertainty	Uncertainty Type	Uncertainty in Excess Reactivity % Δk
Measurement Technique		
	Experimentalists' Estimate	0.0017
	Temperature	0.0024
	Reproducibility	0.0005
	Cents to Δk conversion (β_{eff})	0.0015
	Subtotal	0.0033
Geometry		
	Nominal Plate Dimensions	0.0251
	Matrix Tube Pitch	0.0371
	Subtotal	0.0448
Composition		
	Plutonium	0.0465
	Uranium in Pu-U-Mo Plates	0.0125
	Molybdenum	0.0002
	Sodium	0.0022
	Iron Oxide Plates	0.0230
	Depleted U3O8 Plates	0.0164
	Mild Steel – Axial Reflector	0.0001
	Stainless Steel – Radial Reflector	0.0001
	Stainless Steel – Matrix Tubes	0.0258
	Stainless Steel – Pu Cans	0.0007
	Stainless Steel – Sodium Cans	0.0009
	Stainless Steel – Front Drawers	0.0015
	Stainless Steel – Back Drawers	0.0001
	Humidity	0.0001
	Subtotal	0.0616
	Total	0.0763

Shown in Table 5 are the “Total” uncertainties, by configuration, for all 36 configurations considered, again with the newly approved configurations in red.

Except for the two subcritical cases (SUB-HEU-MET-MIXED-001 and SUB-HEU-MET-FAST-001), the total uncertainties for the new configurations are similar to all the other total uncertainty values.

Table 5. Total Uncertainties for all Assemblies Considered.

Assembly	ICSBEP Number	Total Uncertainty in Excess Reactivity (% Δk)
ZPR-3/6F	IEU-MET-FAST-015	0.1130
ZPR-3/11	IEU-MET-FAST-016	0.1197
ZPR-3/12	IEU-COMP-FAST-004	0.1070
ZPR-3/23	HEU-MET-FAST-055	0.2031
ZPR-3/41	IEU-MET-FAST-012	0.1759
ZPR-3/48	MIX-COMP-FAST-003	0.0687
ZPR-3/48B	MIX-COMP-FAST-003	0.0680
ZPR-3/56B	MIX-COMP-FAST-004	0.1153
ZPR-6/6A	IEU-COMP-INTER-005	0.0939
ZPR-6/7	MIX-COMP-FAST-001	0.0867
ZPR-6/7 High Pu	MIX-COMP-FAST-002	0.0855
ZPR-6/10	PU-MET-INTER-002	0.1270
ZPR-9/1	IEU-MET-FAST-013	0.1018
ZPR-9/2	IEU-MET-FAST-014	0.1009
ZPR-9/3	IEU-MET-FAST-014	0.1015
ZPR-9/4	HEU-MET-FAST-060	0.1142
ZPR-9/5	HEU-MET-FAST-067	0.1120
ZPR-9/6	HEU-MET-FAST-067	0.1176
ZPR-9/7	HEU-MET-FAST-070	0.1220
ZPR-9/8	HEU-MET-FAST-070	0.1249
ZPR-9/9	HEU-MET-FAST-070	0.1183
ZPR-9/31	MIX-COMP-FAST-005	0.1116
ZPR-9/34 U9	IEU-MET-FAST-010	0.1222
ZPR-9/34 U/Fe	HEU-MET-INTER-001	0.1086
ZPPR-2	MIX-COMP-FAST-006	0.0655
ZPPR-12	ZPPR-LMFBR-EXP-010	0.0763
ZPPR-20/C	HEU-MET-FAST-075	0.1645
ZPPR-20/D	HEU-MET-MIXED-012	0.1104
ZPPR-20/Dsub	SUB-HEU-MET-MIXED-001	0.3168
ZPPR-20/Esub	SUB-HEU-MET-FAST-001	0.7159
ZPPR-21A	PU-MET-FAST-033	0.1507
ZPPR-21/B	MIX-MET-FAST-011	0.1434
ZPPR-21/C	MIX-MET-FAST-011	0.1474
ZPPR-21/D	MIX-MET-FAST-011	0.1518
ZPPR-21/E	MIX-MET-FAST-011	0.1655
ZPPR-21/F	HEU-MET-FAST-061	0.1766

There are a total of 2232 (36 x 62) possible uncertainty entries for the 36 ANL benchmark calculations. However, because of the diverse nature of these assemblies, approximately 70% of the possible entries in this overall uncertainty matrix are zero.

The methodology used to create the covariances was discussed in the previous report and will not be presented here. Suffice it to say, the covariance terms ($\rho_{A,B}$) are equal to

$$\rho_{A,B} = \sum_i \frac{\sigma_{Common,A,i}}{\sigma_{Total,A}} * \frac{\sigma_{Common,B,i}}{\sigma_{Total,B}}$$

where A and B are the two assemblies summed over all uncertainty types “i” (see Table 6) of the common fractional uncertainty for assembly A ($\sigma_{Common,i} / \sigma_{Total}$) times the common fractional uncertainty for assembly B ($\sigma_{Common,i} / \sigma_{Total}$). The “Total” uncertainties (σ_{Total}) for each ANL assembly were shown numerically in Table 5.

Notice that in the above equation that the numerators are common (or systematic) uncertainties, and therefore do not include any random uncertainties. In this analysis, common uncertainties are defined as the published uncertainties times a common factor between the two uncertainty types. For example, uranium plates that come from the same fuel “melt” will have a common factor of 1.0, whereas, plates from two different manufactures (or melts) will have a common factor of 0.0.

In this overall analysis, four different types of common factor matrices were used. Matrix 1 had 1’s only for each machine with no interactions with other machines, while Matrix 2 was made especially for steel in matrix tubes. In addition, Matrix 3 had not only 1’s only for each machine, but 1’s for interactions with all other machines. This results because most of the plates were made at ANL-East with the same composition fuel. Matrix 4 was specially made up for plutonium containing plates; it attempts to take into account plates from various independent vendors. The four common-factor matrices are shown in Appendix A.4 of the previous report.

In both the previous report and this report, the above equation and the associated common matrices were “programmed” using an EXCEL spreadsheet. The “program” spreadsheet uses pointers to calculate each covariance value (see above equation). The only input the user has to supply the spreadsheet “program” is the uncertainty type that needs to be calculated and the common matrix to be used for that uncertainty type.

When the three new assemblies were added, the original “program” spreadsheet had to be modified by adding three rows and three columns to the calculated covariance matrix (to account for the three new experiments); the corresponding pointers had to be re-adjusted to point to the correct uncertainty data values.

It turns out that there were 62 totally uncorrelated types of uncertainty identified in the three major uncertainty classes (measurement technique, geometry and composition) for the 36 ANL configurations. Because of the varying makeup of these assemblies, most of these uncertainty types (48 out of 62) are composition related. The 62 distinct uncertainties are listed in Table 6. Also shown in Table 6 are the common matrices that were assigned to each uncertainty type.

Table 6. Distinct Uncertainty Types in ANL Critical Assemblies.

Number	Matrix	Uncertainty Class	Type
1	1	Measurement Technique	Excess Reactivity
2	1	Measurement Technique	Inhours to Δk
3	1	Measurement Technique	Temperature
4	1	Measurement Technique	Reproducibility
5	1	Geometry	Room Return
6	1	Geometry	13 Unknown Reflector Positions
7	1	Geometry	Matrix Interface Gap
8	1	Geometry	Matrix Tube Pitch
9	1	Geometry	Missing Axial Reflector Drawer
10	1	Geometry	Nominal Plate, Drawer Dimensions
11	1	Geometry	Aluminum Perforations
12	1	Geometry	Uranium Axial Distribution
13	1	Geometry	PSR Axial Position
14	1	Geometry	PSR Blades
15	3	Composition	Aluminum in Core
16	3	Composition	Aluminum in Pu-Al Plates
17	1	Composition	Aluminum in Matrix Tubes
18	3	Composition	Aluminum Drawers
19	3	Composition	Aluminum in Reflectors
20	1	Composition	Autorod Blade
21	3	Composition	Beryllium
22	3	Composition	Beryllium Oxide in Reflectors
23	3	Composition	Beryllium Oxide in SP-100 rods
24	3	Composition	Depleted Lithium Plates in core
25	3	Composition	Lithium Hydride in Shield
26	3	Composition	Graphite
27	1	Composition	Graphite in Ax/Rad Refl.
28	4	Composition	Molybdenum in Pu-U-Mo Plates
29	1	Composition	Nickel
30	1	Composition	Niobium
31	1	Composition	Rhenium
32	1	Composition	Sand
33	1	Composition	Sodium
34	3	Composition	Sodium Carbonate
35	1	Composition	Tungsten
36	1	Composition	Zirconium
37	1	Composition	Hydrogen in Zirconium
38	3	Composition	Steel Plates in the Core
39	3	Composition	Steel in the Cans
40	3	Composition	Steel in Drawers
41	2	Composition	Steel in Matrix Tubes
42	3	Composition	Steel in Reflectors

43	3	Composition	Steel in Shield
44	3	Composition	Iron Oxide Plates
45	3	Composition	Enriched Uranium
46	4	Composition	Depleted Uranium in Pu-U-Mo Plates
47	3	Composition	Depleted Uranium in Core
48	3	Composition	Depleted Uranium in Reflectors
49	3	Composition	Depleted Uranium in Blanket
50	3	Composition	Depleted Uranium in Shield
51	3	Composition	Depleted Uranium Oxide Plates
52	4	Composition	Plutonium
53	1	Composition	PSR Blades
54	1	Composition	“Control” Boron Carbide
55	1	Composition	Polyethylene in core
56	1	Composition	Borated Polyethylene in reflector
57	1	Composition	Borated Polyethylene in shield
58	3	Composition	Kel-F on core fuel
59	3	Composition	Kel-F on core DU fuel
60	3	Composition	Kel-F on core BeO plates
61	3	Composition	Kel-F on reflector BeO plates
62	1	Composition	Humidity

When these common-factor matrices were used with the basic uncertainty data and summed over all 62 uncertainty types from Table 6, the total covariance matrix shown graphically in Figure 1 was obtained. (All diagonal terms are unity by definition.) Instead of showing just numbers in a table, it was thought that a color coding scheme gives greater insight into the relationships between assemblies. Figure 2 is a copy of Figure 1, but with the actual covariance values in each grid location.

As seen from either Figure 1 or 2, the most highly correlated data are from three distinct groups; ZPR-3 (Assemblies 6F, 11, 12), ZPR-9 (Assemblies 1-9) and ZPPR-21 (assemblies A-F).

As mentioned before, there are three basic uncertainty classes given in Table 6; measurement, geometry and composition. Shown in Figures 3-5 are the corresponding covariance matrices for these uncertainty classes. A class covariance matrix is the sum of all the basic covariances within that class. From Figures 3-5, it is seen that the composition component is almost always the largest of the three broad group covariance matrices.

When the total covariance numbers are looked at more closely, it was determined that only 6.5% of the 1296 entries (i.e. 36x36) in the total covariance matrix were calculated to be actually zero. Thus, most ANL critical experiments are correlated in some way. The corresponding percentage of zeros in matrices for measurement, geometry and composition covariance uncertainty classes are 72.7%, 72.7% and 6.5%, respectively. Therefore, as seen figuratively from Figures 3-5, the majority of the covariance between ANL assemblies is due to compositional uncertainties.

Finally, Appendix A contains each individual covariance matrix.

Total	ZPR3 0P	ZPR3 23	ZPR3 48	ZPR3 79	ZPR3 101	ZPR3 123	ZPR3 145	ZPR3 167	ZPR3 189	ZPR3 211	ZPR3 233	ZPR3 255	ZPR3 277	ZPR3 300	ZPR3 322	ZPR3 344	ZPR3 366	ZPR3 388	ZPR3 410	ZPR3 432	ZPR3 454	ZPR3 476	ZPR3 498	ZPR3 520	ZPR3 542	ZPR3 564	ZPR3 586	ZPR3 608	ZPR3 630	ZPR3 652	ZPR3 674	ZPR3 696	ZPR3 718	ZPR3 740	ZPR3 762	ZPR3 784	ZPR3 806	ZPR3 828	ZPR3 850	ZPR3 872	ZPR3 894	ZPR3 916	ZPR3 938	ZPR3 960	ZPR3 982	ZPR3 1004	ZPR3 1026	ZPR3 1048	ZPR3 1070	ZPR3 1092	ZPR3 1114	ZPR3 1136	ZPR3 1158	ZPR3 1180	ZPR3 1202	ZPR3 1224	ZPR3 1246	ZPR3 1268	ZPR3 1290	ZPR3 1312	ZPR3 1334	ZPR3 1356	ZPR3 1378	ZPR3 1400	ZPR3 1422	ZPR3 1444	ZPR3 1466	ZPR3 1488	ZPR3 1510	ZPR3 1532	ZPR3 1554	ZPR3 1576	ZPR3 1598	ZPR3 1620	ZPR3 1642	ZPR3 1664	ZPR3 1686	ZPR3 1708	ZPR3 1730	ZPR3 1752	ZPR3 1774	ZPR3 1796	ZPR3 1818	ZPR3 1840	ZPR3 1862	ZPR3 1884	ZPR3 1906	ZPR3 1928	ZPR3 1950	ZPR3 1972	ZPR3 1994	ZPR3 2016	ZPR3 2038	ZPR3 2060	ZPR3 2082	ZPR3 2104	ZPR3 2126	ZPR3 2148	ZPR3 2170	ZPR3 2192	ZPR3 2214	ZPR3 2236	ZPR3 2258	ZPR3 2280	ZPR3 2302	ZPR3 2324	ZPR3 2346	ZPR3 2368	ZPR3 2390	ZPR3 2412	ZPR3 2434	ZPR3 2456	ZPR3 2478	ZPR3 2500	ZPR3 2522	ZPR3 2544	ZPR3 2566	ZPR3 2588	ZPR3 2610	ZPR3 2632	ZPR3 2654	ZPR3 2676	ZPR3 2698	ZPR3 2720	ZPR3 2742	ZPR3 2764	ZPR3 2786	ZPR3 2808	ZPR3 2830	ZPR3 2852	ZPR3 2874	ZPR3 2896	ZPR3 2918	ZPR3 2940	ZPR3 2962	ZPR3 2984	ZPR3 3006	ZPR3 3028	ZPR3 3050	ZPR3 3072	ZPR3 3094	ZPR3 3116	ZPR3 3138	ZPR3 3160	ZPR3 3182	ZPR3 3204	ZPR3 3226	ZPR3 3248	ZPR3 3270	ZPR3 3292	ZPR3 3314	ZPR3 3336	ZPR3 3358	ZPR3 3380	ZPR3 3402	ZPR3 3424	ZPR3 3446	ZPR3 3468	ZPR3 3490	ZPR3 3512	ZPR3 3534	ZPR3 3556	ZPR3 3578	ZPR3 3600	ZPR3 3622	ZPR3 3644	ZPR3 3666	ZPR3 3688	ZPR3 3710	ZPR3 3732	ZPR3 3754	ZPR3 3776	ZPR3 3798	ZPR3 3820	ZPR3 3842	ZPR3 3864	ZPR3 3886	ZPR3 3908	ZPR3 3930	ZPR3 3952	ZPR3 3974	ZPR3 3996	ZPR3 4018	ZPR3 4040	ZPR3 4062	ZPR3 4084	ZPR3 4106	ZPR3 4128	ZPR3 4150	ZPR3 4172	ZPR3 4194	ZPR3 4216	ZPR3 4238	ZPR3 4260	ZPR3 4282	ZPR3 4304	ZPR3 4326	ZPR3 4348	ZPR3 4370	ZPR3 4392	ZPR3 4414	ZPR3 4436	ZPR3 4458	ZPR3 4480	ZPR3 4502	ZPR3 4524	ZPR3 4546	ZPR3 4568	ZPR3 4590	ZPR3 4612	ZPR3 4634	ZPR3 4656	ZPR3 4678	ZPR3 4700	ZPR3 4722	ZPR3 4744	ZPR3 4766	ZPR3 4788	ZPR3 4810	ZPR3 4832	ZPR3 4854	ZPR3 4876	ZPR3 4898	ZPR3 4920	ZPR3 4942	ZPR3 4964	ZPR3 4986	ZPR3 5008	ZPR3 5030	ZPR3 5052	ZPR3 5074	ZPR3 5096	ZPR3 5118	ZPR3 5140	ZPR3 5162	ZPR3 5184	ZPR3 5206	ZPR3 5228	ZPR3 5250	ZPR3 5272	ZPR3 5294	ZPR3 5316	ZPR3 5338	ZPR3 5360	ZPR3 5382	ZPR3 5404	ZPR3 5426	ZPR3 5448	ZPR3 5470	ZPR3 5492	ZPR3 5514	ZPR3 5536	ZPR3 5558	ZPR3 5580	ZPR3 5602	ZPR3 5624	ZPR3 5646	ZPR3 5668	ZPR3 5690	ZPR3 5712	ZPR3 5734	ZPR3 5756	ZPR3 5778	ZPR3 5800	ZPR3 5822	ZPR3 5844	ZPR3 5866	ZPR3 5888	ZPR3 5910	ZPR3 5932	ZPR3 5954	ZPR3 5976	ZPR3 5998	ZPR3 6020	ZPR3 6042	ZPR3 6064	ZPR3 6086	ZPR3 6108	ZPR3 6130	ZPR3 6152	ZPR3 6174	ZPR3 6196	ZPR3 6218	ZPR3 6240	ZPR3 6262	ZPR3 6284	ZPR3 6306	ZPR3 6328	ZPR3 6350	ZPR3 6372	ZPR3 6394	ZPR3 6416	ZPR3 6438	ZPR3 6460	ZPR3 6482	ZPR3 6504	ZPR3 6526	ZPR3 6548	ZPR3 6570	ZPR3 6592	ZPR3 6614	ZPR3 6636	ZPR3 6658	ZPR3 6680	ZPR3 6702	ZPR3 6724	ZPR3 6746	ZPR3 6768	ZPR3 6790	ZPR3 6812	ZPR3 6834	ZPR3 6856	ZPR3 6878	ZPR3 6900	ZPR3 6922	ZPR3 6944	ZPR3 6966	ZPR3 6988	ZPR3 7010	ZPR3 7032	ZPR3 7054	ZPR3 7076	ZPR3 7098	ZPR3 7120	ZPR3 7142	ZPR3 7164	ZPR3 7186	ZPR3 7208	ZPR3 7230	ZPR3 7252	ZPR3 7274	ZPR3 7296	ZPR3 7318	ZPR3 7340	ZPR3 7362	ZPR3 7384	ZPR3 7406	ZPR3 7428	ZPR3 7450	ZPR3 7472	ZPR3 7494	ZPR3 7516	ZPR3 7538	ZPR3 7560	ZPR3 7582	ZPR3 7604	ZPR3 7626	ZPR3 7648	ZPR3 7670	ZPR3 7692	ZPR3 7714	ZPR3 7736	ZPR3 7758	ZPR3 7780	ZPR3 7802	ZPR3 7824	ZPR3 7846	ZPR3 7868	ZPR3 7890	ZPR3 7912	ZPR3 7934	ZPR3 7956	ZPR3 7978	ZPR3 8000	ZPR3 8022	ZPR3 8044	ZPR3 8066	ZPR3 8088	ZPR3 8110	ZPR3 8132	ZPR3 8154	ZPR3 8176	ZPR3 8198	ZPR3 8220	ZPR3 8242	ZPR3 8264	ZPR3 8286	ZPR3 8308	ZPR3 8330	ZPR3 8352	ZPR3 8374	ZPR3 8396	ZPR3 8418	ZPR3 8440	ZPR3 8462	ZPR3 8484	ZPR3 8506	ZPR3 8528	ZPR3 8550	ZPR3 8572	ZPR3 8594	ZPR3 8616	ZPR3 8638	ZPR3 8660	ZPR3 8682	ZPR3 8704	ZPR3 8726	ZPR3 8748	ZPR3 8770	ZPR3 8792	ZPR3 8814	ZPR3 8836	ZPR3 8858	ZPR3 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10970	ZPR3 10992	ZPR3 11014	ZPR3 11036	ZPR3 11058	ZPR3 11080	ZPR3 11102	ZPR3 11124	ZPR3 11146	ZPR3 11168	ZPR3 11190	ZPR3 11212	ZPR3 11234	ZPR3 11256	ZPR3 11278	ZPR3 11300	ZPR3 11322	ZPR3 11344	ZPR3 11366	ZPR3 11388	ZPR3 11410	ZPR3 11432	ZPR3 11454	ZPR3 11476	ZPR3 11498	ZPR3 11520	ZPR3 11542	ZPR3 11564	ZPR3 11586	ZPR3 11608	ZPR3 11630	ZPR3 11652	ZPR3 11674	ZPR3 11696	ZPR3 11718	ZPR3 11740	ZPR3 11762	ZPR3 11784	ZPR3 11806	ZPR3 11828	ZPR3 11850	ZPR3 11872	ZPR3 11894	ZPR3 11916	ZPR3 11938	ZPR3 11960	ZPR3 11982	ZPR3 12004	ZPR3 12026	ZPR3 12048	ZPR3 12070	ZPR3 12092	ZPR3 12114	ZPR3 12136	ZPR3 12158	ZPR3 12180	ZPR3 12202	ZPR3 12224	ZPR3 12246	ZPR3 12268	ZPR3 12290	ZPR3 12312	ZPR3 12334	ZPR3 12356	ZPR3 12378	ZPR3 12400	ZPR3 12422	ZPR3 12444	ZPR3 12466	ZPR3 12488	ZPR3 12510	ZPR3 12532	ZPR3 12554	ZPR3 12576	ZPR3 12598	ZPR3 12620	ZPR3 12642	ZPR3 12664	ZPR3 12686	ZPR3 12708	ZPR3 12730	ZPR3 12752	ZPR3 12774	ZPR3 12796	ZPR3 12818	ZPR3 12840	ZPR3 12862	ZPR3 12884	ZPR3 12906	ZPR3 12928	ZPR3 12950	ZPR3 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14974	ZPR3 14996	ZPR3 15018	ZPR3 15040	ZPR3 15062	ZPR3 15084	ZPR3 15106	ZPR3 15128	ZPR3 15150	ZPR3 15172	ZPR3 15194	ZPR3 15216	ZPR3 15238	ZPR3 15260	ZPR3 15282	ZPR3 15304	ZPR3 15326	ZPR3 15348	ZPR3 15370	ZPR3 15392	ZPR3 15414	ZPR3 15436	ZPR3 15458	ZPR3 15480	ZPR3 15502	ZPR3 15524	ZPR3 15546	ZPR3 15568	ZPR3 15590	ZPR3 15612	ZPR3 15634	ZPR3 15656	ZPR3 15678	ZPR3 15700	ZPR3 15722	ZPR3 15744	ZPR3 15766	ZPR3 15788	ZPR3 15810	ZPR3 15832	ZPR3 15854	ZPR3 15876	ZPR3 15898	ZPR3 15920	ZPR3 15942	ZPR3 15964	ZPR3 15986	ZPR3 16008	ZPR3 16030	ZPR3 16052	ZPR3 16074	ZPR3 16096	ZPR3 16118	ZPR3 16140	ZPR3 16162	ZPR3 16184	ZPR3 16206	ZPR3 16228	ZPR3 16250	ZPR3 16272	ZPR3 16294	ZPR3 16316	ZPR3 16338	ZPR3 16360	ZPR3 16382	ZPR3 16404	ZPR3 16426	ZPR3 16448	ZPR3 16470	ZPR3 16492	ZPR3 16514	ZPR3 16536	ZPR3 16558	ZPR3 16580	ZPR3 16602	ZPR3 16624	ZPR3 16646	ZPR3 16668	ZPR3 16690	ZPR3 16712	ZPR3 16734	ZPR3 16756	ZPR3 16778	ZPR3 16800	ZPR3 16822	ZPR3 16844	ZPR3 16866	ZPR3 16888	ZPR3 16910	ZPR3 16932	ZPR3 16954	ZPR3 16976	ZPR3 16998	ZPR3 17020	ZPR3 17042	ZPR3 17064	ZPR3 17086	ZPR3 17108	ZPR3 17130	ZPR3 17152	ZPR3 17174	ZPR3 17196	ZPR3 17218	ZPR3 17240	ZPR3 17262	ZPR3 17284	ZPR3 17306	ZPR3 17328	ZPR3 17350	ZPR3 17372	ZPR3 17394	ZPR3 17416	ZPR3 17438	ZPR3 17460	ZPR3 17482	ZPR3 17504	ZPR3 17526	ZPR3 17548	ZPR3 17570	ZPR3 17592	ZPR3 17614	ZPR3 17636	ZPR3 17658	ZPR3 17680	ZPR3 17702	ZPR3 17724	ZPR3 17746	ZPR3 17768	ZPR3 17790	ZPR3 17812	ZPR3 17834	ZPR3 17856	ZPR3 17878	ZPR3 17900	ZPR3 17922	ZPR3 17944	ZPR3 17966	ZPR3 17988	ZPR3 18010	ZPR3 18032	ZPR3 18054	ZPR3 18076	ZPR3 18098	ZPR3 18120	ZPR3 18142	ZPR3 18164	ZPR3 18186	ZPR3 18208	ZPR3 18230	ZPR3 18252	ZPR3 18274	ZPR3 18296	ZPR3 18318	ZPR3 18340	ZPR3 18362	ZPR3 18384	ZPR3 18406	ZPR3 18428	ZPR3 18450	ZPR3 18472	ZPR3 18494	ZPR3 18516	ZPR3 18538	ZPR3 18560	ZPR3 18582	ZPR3 18604	ZPR3 18626	ZPR3 18648	ZPR3 18670	ZPR3 18692	ZPR3 18714	ZPR3 18736	ZPR3 18758	ZPR3 18780	ZPR3 18802	ZPR3 18824	ZPR3 18846	ZPR3 18868	ZPR3 18890	ZPR3 18912	ZPR3 18934	ZPR3 18956	ZPR3 18978	ZPR3 19000	ZPR3 19022	ZPR3 19044	ZPR3 19066	ZPR3 19088	ZPR3 19110	ZPR3 19132	ZPR3 19154	ZPR3 19176	ZPR3 19198	ZPR3 19220	ZPR3 19242	ZPR3 19264	ZPR3 19286	ZPR3 19308	ZPR3 19330	ZPR3 19352	ZPR3 19374	ZPR3 19396	ZPR3 19418	ZPR3 19440	ZPR3 19462	ZPR3 19484	ZPR3 19506	ZPR3 19528	ZPR3 19550	ZPR3 19572	ZPR3 19594	ZPR3 19616	ZPR3 19638	ZPR3 19660	ZPR3 19682	ZPR3 19704	ZPR3 19726	ZPR3 19748	ZPR3 19770	ZPR3 19792	ZPR3 19814	ZPR3 19836	ZPR3 19858	ZPR3 19880	ZPR3 19902	ZPR3 19924	ZPR3 19946	ZPR3 19968	ZPR3 19990	ZPR3 20012	ZPR3 20034	ZPR3 20056	ZPR3 20078	ZPR3 20100	ZPR3 20122	ZPR3 20144	ZPR3 20166	ZPR3 20188
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[illegible]

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References

- 1) Tatiana Ivanova, et. al., "Towards validation of criticality calculations for systems with MOX powders," Annals of Nuclear Energy, 36 (2009) 305-309.
- 2) M. Ishikawa, "How to Determine Error Matrix of Integral Data, Appendix A," Draft, November 25, 2011. **(MORE definition is needed for this reference.)**

Appendix A. Supplementary Figures

Appendix A contains the covariance matrices for each of the 62 uncertainty types given in Table 6 for all 36 experiments considered.

[illegible]

Figure A3. Temperature Covariance Matrix for 36 ANL Benchmarks.

Figure A6. 13 Unknown Reflector Positions Covariance Matrix for 36 ANL Benchmarks.

0.00 - 0.05	0.05 - 0.10	0.10 - 0.15	0.15 - 0.20	0.20 - 0.25	0.25 - 0.30	0.30 - 0.35	0.35 - 0.40	0.40 - 0.45	0.45 - 0.50	0.50 - 0.55	0.55 - 0.60	0.60 - 0.65	0.65 - 0.70	0.70 - 0.75	0.75 - 0.80	0.80 - 0.85	0.85 - 0.90	0.90 - 0.95	0.95 - 1.00
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Figure A9. Missing Axial Reflector Drawer Covariance Matrix for 36 ANL Benchmarks.

[illegible]

Figure A11. Aluminum Perforations Covariance Matrix for 36 ANL Benchmarks.

[illegible]

Figure A12. Uranium Axial Distribution Covariance Matrix for 36 ANL Benchmarks.

PSR Axis Position	ZPR3 9F	ZPR3 11	ZPR3 12	ZPR3 23	ZPR3 41	ZPR3 48	ZPR3 56B	ZPR6 6A	ZPR6 7	ZPR6 7Fu	ZPR6 9U9	ZPR6 10	ZPR6 1	ZPR6 2	ZPR6 3	ZPR6 4	ZPR6 5	ZPR6 6	ZPR6 7	ZPR6 8	ZPR6 9	ZPR6 31	ZPR6 JFE	ZPR6 2	ZPR6 12	ZPR6 20C	ZPR6 20D	ZPR6 20E	ZPR6 20F	ZPR6 20G	ZPR6 20H	ZPR6 20I	ZPR6 20J	ZPR6 20K	ZPR6 20L	ZPR6 20M	ZPR6 20N	ZPR6 20O	ZPR6 20P	ZPR6 20Q	ZPR6 20R	ZPR6 20S	ZPR6 20T	ZPR6 20U	ZPR6 20V	ZPR6 20W	ZPR6 20X	ZPR6 20Y	ZPR6 20Z	ZPR6 20AA	ZPR6 20AB	ZPR6 20AC	ZPR6 20AD	ZPR6 20AE	ZPR6 20AF	ZPR6 20AG	ZPR6 20AH	ZPR6 20AI	ZPR6 20AJ	ZPR6 20AK	ZPR6 20AL	ZPR6 20AM	ZPR6 20AN	ZPR6 20AO	ZPR6 20AP	ZPR6 20AQ	ZPR6 20AR	ZPR6 20AS	ZPR6 20AT	ZPR6 20AU	ZPR6 20AV	ZPR6 20AW	ZPR6 20AX	ZPR6 20AY	ZPR6 20AZ	ZPR6 20BA	ZPR6 20BB	ZPR6 20BC	ZPR6 20BD	ZPR6 20BE	ZPR6 20BF	ZPR6 20BG	ZPR6 20BH	ZPR6 20BI	ZPR6 20BJ	ZPR6 20BK	ZPR6 20BL	ZPR6 20BM	ZPR6 20BN	ZPR6 20BO	ZPR6 20BP	ZPR6 20BQ	ZPR6 20BR	ZPR6 20BS	ZPR6 20BT	ZPR6 20BU	ZPR6 20BV	ZPR6 20BW	ZPR6 20BX	ZPR6 20BY	ZPR6 20BZ	ZPR6 20CA	ZPR6 20CB	ZPR6 20CC	ZPR6 20CD	ZPR6 20CE	ZPR6 20CF	ZPR6 20CG	ZPR6 20CH	ZPR6 20CI	ZPR6 20CJ	ZPR6 20CK	ZPR6 20CL	ZPR6 20CM	ZPR6 20CN	ZPR6 20CO	ZPR6 20CP	ZPR6 20CQ	ZPR6 20CR	ZPR6 20CS	ZPR6 20CT	ZPR6 20CU	ZPR6 20CV	ZPR6 20CW	ZPR6 20CX	ZPR6 20CY	ZPR6 20CZ	ZPR6 20DA	ZPR6 20DB	ZPR6 20DC	ZPR6 20DD	ZPR6 20DE	ZPR6 20DF	ZPR6 20DG	ZPR6 20DH	ZPR6 20DI	ZPR6 20DJ	ZPR6 20DK	ZPR6 20DL	ZPR6 20DM	ZPR6 20DN	ZPR6 20DO	ZPR6 20DP	ZPR6 20DQ	ZPR6 20DR	ZPR6 20DS	ZPR6 20DT	ZPR6 20DU	ZPR6 20DV	ZPR6 20DW	ZPR6 20DX	ZPR6 20DY	ZPR6 20DZ	ZPR6 20EA	ZPR6 20EB	ZPR6 20EC	ZPR6 20ED	ZPR6 20EE	ZPR6 20EF	ZPR6 20EG	ZPR6 20EH	ZPR6 20EI	ZPR6 20EJ	ZPR6 20EK	ZPR6 20EL	ZPR6 20EM	ZPR6 20EN	ZPR6 20EO	ZPR6 20EP	ZPR6 20EQ	ZPR6 20ER	ZPR6 20ES	ZPR6 20ET	ZPR6 20EU	ZPR6 20EV	ZPR6 20EW	ZPR6 20EX	ZPR6 20EY	ZPR6 20EZ	ZPR6 20FA	ZPR6 20FB	ZPR6 20FC	ZPR6 20FD	ZPR6 20FE	ZPR6 20FF	ZPR6 20FG	ZPR6 20FH	ZPR6 20FI	ZPR6 20FJ	ZPR6 20FK	ZPR6 20FL	ZPR6 20FM	ZPR6 20FN	ZPR6 20FO	ZPR6 20FP	ZPR6 20FQ	ZPR6 20FR	ZPR6 20FS	ZPR6 20FT	ZPR6 20FU	ZPR6 20FV	ZPR6 20FW	ZPR6 20FX	ZPR6 20FY	ZPR6 20FZ	ZPR6 20GA	ZPR6 20GB	ZPR6 20GC	ZPR6 20GD	ZPR6 20GE	ZPR6 20GF	ZPR6 20GG	ZPR6 20GH	ZPR6 20GI	ZPR6 20GJ	ZPR6 20GK	ZPR6 20GL	ZPR6 20GM	ZPR6 20GN	ZPR6 20GO	ZPR6 20GP	ZPR6 20GQ	ZPR6 20GR	ZPR6 20GS	ZPR6 20GT	ZPR6 20GU	ZPR6 20GV	ZPR6 20GW	ZPR6 20GX	ZPR6 20GY	ZPR6 20GZ	ZPR6 20HA	ZPR6 20HB	ZPR6 20HC	ZPR6 20HD	ZPR6 20HE	ZPR6 20HF	ZPR6 20HG	ZPR6 20HH	ZPR6 20HI	ZPR6 20HJ	ZPR6 20HK	ZPR6 20HL	ZPR6 20HM	ZPR6 20HN	ZPR6 20HO	ZPR6 20HP	ZPR6 20HQ	ZPR6 20HR	ZPR6 20HS	ZPR6 20HT	ZPR6 20HU	ZPR6 20HV	ZPR6 20HW	ZPR6 20HX	ZPR6 20HY	ZPR6 20HZ	ZPR6 20IA	ZPR6 20IB	ZPR6 20IC	ZPR6 20ID	ZPR6 20IE	ZPR6 20IF	ZPR6 20IG	ZPR6 20IH	ZPR6 20II	ZPR6 20IJ	ZPR6 20IK	ZPR6 20IL	ZPR6 20IM	ZPR6 20IN	ZPR6 20IO	ZPR6 20IP	ZPR6 20IQ	ZPR6 20IR	ZPR6 20IS	ZPR6 20IT	ZPR6 20IU	ZPR6 20IV	ZPR6 20IW	ZPR6 20IX	ZPR6 20IY	ZPR6 20IZ	ZPR6 20JA	ZPR6 20JB	ZPR6 20JC	ZPR6 20JD	ZPR6 20JE	ZPR6 20JF	ZPR6 20JG	ZPR6 20JH	ZPR6 20JI	ZPR6 20JJ	ZPR6 20JK	ZPR6 20JL	ZPR6 20JM	ZPR6 20JN	ZPR6 20JO	ZPR6 20JP	ZPR6 20JQ	ZPR6 20JR	ZPR6 20JS	ZPR6 20JT	ZPR6 20JU	ZPR6 20JV	ZPR6 20JW	ZPR6 20JX	ZPR6 20JY	ZPR6 20JZ	ZPR6 20KA	ZPR6 20KB	ZPR6 20KC	ZPR6 20KD	ZPR6 20KE	ZPR6 20KF	ZPR6 20KG	ZPR6 20KH	ZPR6 20KI	ZPR6 20KJ	ZPR6 20KK	ZPR6 20KL	ZPR6 20KM	ZPR6 20KN	ZPR6 20KO	ZPR6 20KP	ZPR6 20KQ	ZPR6 20KR	ZPR6 20KS	ZPR6 20KT	ZPR6 20KU	ZPR6 20KV	ZPR6 20KW	ZPR6 20KX	ZPR6 20KY	ZPR6 20KZ	ZPR6 20LA	ZPR6 20LB	ZPR6 20LC	ZPR6 20LD	ZPR6 20LE	Z
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Figure A13. PSR Axial Position Covariance Matrix for 36 ANL Benchmarks.

PSR Axial Position	ZPR3 0F	ZPR3 11	ZPR3 12	ZPR3 23	ZPR3 41	ZPR3 48	ZPR3 48B	ZPR3 54B	ZPR6 6A	ZPR6 7P4	ZPR6 9U9	ZPR6 10	ZPR9 1	ZPR9 2	ZPR9 3	ZPR9 8	ZPR9 7	ZPR9 6	ZPR9 5	ZPR9 4	ZPR9 3	ZPR9 2	ZPR9 3	ZPR9 4	ZPR9 5	ZPR9 6	ZPR9 7	ZPR9 8	ZPR9 9	ZPR9 10	ZPR9 11	ZPR9 12	ZPR9 13	ZPR9 14	ZPR9 15	ZPR9 16	ZPR9 17	ZPR9 18	ZPR9 19	ZPR9 20	ZPR9 21	ZPR9 22	ZPR9 23	ZPR9 24	ZPR9 25	ZPR9 26	ZPR9 27	ZPR9 28	ZPR9 29	ZPR9 30	ZPR9 31	ZPR9 34	ZPR9 12	ZPR9 20C	ZPR9 20E	ZPR9 21A	ZPR9 21B	ZPR9 21C	ZPR9 21D	ZPR9 21E	ZPR9 21F	ZPR9 21G	ZPR9 21H	ZPR9 21I	ZPR9 21J	ZPR9 21K	ZPR9 21L	ZPR9 21M	ZPR9 21N	ZPR9 21O	ZPR9 21P	ZPR9 21Q	ZPR9 21R	ZPR9 21S	ZPR9 21T	ZPR9 21U	ZPR9 21V	ZPR9 21W	ZPR9 21X	ZPR9 21Y	ZPR9 21Z	ZPR9 21AA	ZPR9 21AB	ZPR9 21AC	ZPR9 21AD	ZPR9 21AE	ZPR9 21AF	ZPR9 21AG	ZPR9 21AH	ZPR9 21AI	ZPR9 21AJ	ZPR9 21AK	ZPR9 21AL	ZPR9 21AM	ZPR9 21AN	ZPR9 21AO	ZPR9 21AP	ZPR9 21AQ	ZPR9 21AR	ZPR9 21AS	ZPR9 21AT	ZPR9 21AU	ZPR9 21AV	ZPR9 21AW	ZPR9 21AX	ZPR9 21AY	ZPR9 21AZ	ZPR9 21BA	ZPR9 21BB	ZPR9 21BC	ZPR9 21BD	ZPR9 21BE	ZPR9 21BF	ZPR9 21BG	ZPR9 21BH	ZPR9 21BI	ZPR9 21BJ	ZPR9 21BK	ZPR9 21BL	ZPR9 21BM	ZPR9 21BN	ZPR9 21BO	ZPR9 21BP	ZPR9 21BQ	ZPR9 21BR	ZPR9 21BS	ZPR9 21BT	ZPR9 21BU	ZPR9 21BV	ZPR9 21BW	ZPR9 21BX	ZPR9 21BY	ZPR9 21BZ	ZPR9 21CA	ZPR9 21CB	ZPR9 21CC	ZPR9 21CD	ZPR9 21CE	ZPR9 21CF	ZPR9 21CG	ZPR9 21CH	ZPR9 21CI	ZPR9 21CJ	ZPR9 21CK	ZPR9 21CL	ZPR9 21CM	ZPR9 21CN	ZPR9 21CO	ZPR9 21CP	ZPR9 21CQ	ZPR9 21CR	ZPR9 21CS	ZPR9 21CT	ZPR9 21CU	ZPR9 21CV	ZPR9 21CW	ZPR9 21CX	ZPR9 21CY	ZPR9 21CZ	ZPR9 21DA	ZPR9 21DB	ZPR9 21DC	ZPR9 21DD	ZPR9 21DE	ZPR9 21DF	ZPR9 21DG	ZPR9 21DH	ZPR9 21DI	ZPR9 21DJ	ZPR9 21DK	ZPR9 21DL	ZPR9 21DM	ZPR9 21DN	ZPR9 21DO	ZPR9 21DP	ZPR9 21DQ	ZPR9 21DR	ZPR9 21DS	ZPR9 21DT	ZPR9 21DU	ZPR9 21DV	ZPR9 21DW	ZPR9 21DX	ZPR9 21DY	ZPR9 21DZ	ZPR9 21EA	ZPR9 21EB	ZPR9 21EC	ZPR9 21ED	ZPR9 21EE	ZPR9 21EF	ZPR9 21EG	ZPR9 21EH	ZPR9 21EI	ZPR9 21EJ	ZPR9 21EK	ZPR9 21EL	ZPR9 21EM	ZPR9 21EN	ZPR9 21EO	ZPR9 21EP	ZPR9 21EQ	ZPR9 21ER	ZPR9 21ES	ZPR9 21ET	ZPR9 21EU	ZPR9 21EV	ZPR9 21EW	ZPR9 21EX	ZPR9 21EY	ZPR9 21EZ	ZPR9 21FA	ZPR9 21FB	ZPR9 21FC	ZPR9 21FD	ZPR9 21FE	ZPR9 21FF	ZPR9 21FG	ZPR9 21FH	ZPR9 21FI	ZPR9 21FJ	ZPR9 21FK	ZPR9 21FL	ZPR9 21FM	ZPR9 21FN	ZPR9 21FO	ZPR9 21FP	ZPR9 21FQ	ZPR9 21FR	ZPR9 21FS	ZPR9 21FT	ZPR9 21FU	ZPR9 21FV	ZPR9 21FW	ZPR9 21FX	ZPR9 21FY	ZPR9 21FZ	ZPR9 21GA	ZPR9 21GB	ZPR9 21GC	ZPR9 21GD	ZPR9 21GE	ZPR9 21GF	ZPR9 21GG	ZPR9 21GH	ZPR9 21GI	ZPR9 21GJ	ZPR9 21GK	ZPR9 21GL	ZPR9 21GM	ZPR9 21GN	ZPR9 21GO	ZPR9 21GP	ZPR9 21GQ	ZPR9 21GR	ZPR9 21GS	ZPR9 21GT	ZPR9 21GU	ZPR9 21GV	ZPR9 21GW	ZPR9 21GX	ZPR9 21GY	ZPR9 21GZ	ZPR9 21HA	ZPR9 21HB	ZPR9 21HC	ZPR9 21HD	ZPR9 21HE	ZPR9 21HF	ZPR9 21HG	ZPR9 21HH	ZPR9 21HI	ZPR9 21HJ	ZPR9 21HK	ZPR9 21HL
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Figure A14. PSR Blades Covariance Matrix for 36 ANL Benchmarks.

[illegible]

Figure A15. Aluminum in Core Covariance Matrix for 36 ANL Benchmarks.

[illegible]

Figure A17. Aluminum in Matrix Tubes Covariance Matrix for 36 ANL Benchmarks.

[illegible]

34

[illegible]

Figure A23. Beryllium Oxide in SP-100 Rods Covariance Matrix for 36 ANL Benchmarks.

[illegible]

Figure A25. Lithium Hydride in Shield Covariance Matrix for 36 ANL Benchmarks.

Graphite	ZPR3 6F	ZPR3 11	ZPR3 12	ZPR3 23	ZPR3 41	ZPR3 48	ZPR3 48B	ZPR3 54B	ZPR6 6A	ZPR6 7	ZPR6 7PU	ZPR6 9 U	ZPR6 10	ZPR9 1	ZPR9 2	ZPR9 3	ZPR9 4	ZPR9 5	ZPR9 6	ZPR9 7	ZPR9 8	ZPR9 9	ZPR9 31	ZPR9 LIFE	ZPR9 2	12	20C	20D	20D- 20E	ZPR9 21A	ZPR9 21B	ZPR9 21C	ZPR9 21D	ZPR9 21E	ZPR9 21F	0.00-0.05	0.05-0.10	0.10-0.15	0.15-0.20	0.20-0.25	0.25-0.30	0.30-0.35	0.35-0.40	0.40-0.45	0.45-0.50	0.50-0.55	0.55-0.60	0.60-0.65	0.65-0.70	0.70-0.75	0.75-0.80	0.80-0.85	0.85-0.90	0.90-0.95	0.95-1.00	1.00-1.05	1.05-1.10	1.10-1.15	1.15-1.20	1.20-1.25	1.25-1.30	1.30-1.35	1.35-1.40	1.40-1.45	1.45-1.50	1.50-1.55	1.55-1.60	1.60-1.65	1.65-1.70	1.70-1.75	1.75-1.80	1.80-1.85	1.85-1.90	1.90-1.95	1.95-2.00	2.00-2.05	2.05-2.10	2.10-2.15	2.15-2.20	2.20-2.25	2.25-2.30	2.30-2.35	2.35-2.40	2.40-2.45	2.45-2.50	2.50-2.55	2.55-2.60	2.60-2.65	2.65-2.70	2.70-2.75	2.75-2.80	2.80-2.85	2.85-2.90	2.90-2.95	2.95-3.00	3.00-3.05	3.05-3.10	3.10-3.15	3.15-3.20	3.20-3.25	3.25-3.30	3.30-3.35	3.35-3.40	3.40-3.45	3.45-3.50	3.50-3.55	3.55-3.60	3.60-3.65	3.65-3.70	3.70-3.75	3.75-3.80	3.80-3.85	3.85-3.90	3.90-3.95	3.95-4.00	4.00-4.05	4.05-4.10	4.10-4.15	4.15-4.20	4.20-4.25	4.25-4.30	4.30-4.35	4.35-4.40	4.40-4.45	4.45-4.50	4.50-4.55	4.55-4.60	4.60-4.65	4.65-4.70	4.70-4.75	4.75-4.80	4.80-4.85	4.85-4.90	4.90-4.95	4.95-5.00	5.00-5.05	5.05-5.10	5.10-5.15	5.15-5.20	5.20-5.25	5.25-5.30	5.30-5.35	5.35-5.40	5.40-5.45	5.45-5.50	5.50-5.55	5.55-5.60	5.60-5.65	5.65-5.70	5.70-5.75	5.75-5.80	5.80-5.85	5.85-5.90	5.90-5.95	5.95-6.00	6.00-6.05	6.05-6.10	6.10-6.15	6.15-6.20	6.20-6.25	6.25-6.30	6.30-6.35	6.35-6.40	6.40-6.45	6.45-6.50	6.50-6.55	6.55-6.60	6.60-6.65	6.65-6.70	6.70-6.75	6.75-6.80	6.80-6.85	6.85-6.90	6.90-6.95	6.95-7.00	7.00-7.05	7.05-7.10	7.10-7.15	7.15-7.20	7.20-7.25	7.25-7.30	7.30-7.35	7.35-7.40	7.40-7.45	7.45-7.50	7.50-7.55	7.55-7.60	7.60-7.65	7.65-7.70	7.70-7.75	7.75-7.80	7.80-7.85	7.85-7.90	7.90-7.95	7.95-8.00	8.00-8.05	8.05-8.10	8.10-8.15	8.15-8.20	8.20-8.25	8.25-8.30	8.30-8.35	8.35-8.40	8.40-8.45	8.45-8.50	8.50-8.55	8.55-8.60	8.60-8.65	8.65-8.70	8.70-8.75	8.75-8.80	8.80-8.85	8.85-8.90	8.90-8.95	8.95-9.00	9.00-9.05	9.05-9.10	9.10-9.15	9.15-9.20	9.20-9.25	9.25-9.30	9.30-9.35	9.35-9.40	9.40-9.45	9.45-9.50	9.50-9.55	9.55-9.60	9.60-9.65	9.65-9.70	9.70-9.75	9.75-9.80	9.80-9.85	9.85-9.90	9.90-9.95	10.00-10.05	10.05-10.10	10.10-10.15	10.15-10.20	10.20-10.25	10.25-10.30	10.30-10.35	10.35-10.40	10.40-10.45	10.45-10.50
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Figure A26. Graphite Covariance Matrix for 36 ANL Benchmarks.

[illegible]

Figure A29. Nickel Covariance Matrix for 36 ANL Benchmarks.

[illegible]

Figure A35. Tungsten Covariance Matrix for 36 ANL Benchmarks.

Zirconium	ZrP3 6F	ZrP3 11	ZrP3 12	ZrP3 23	ZrP3 41	ZrP3 48	ZrP3 48B	ZrP3 56B	ZrP6 6A	ZrP6 7	ZrP6 7Pu	ZrP6 9U9	ZrP6 10	ZrP6 1	ZrP9 2	ZrP9 3	ZrP9 4	ZrP9 5	ZrP9 6	ZrP9 7	ZrP9 8	ZrP9 9	ZrP9 31	ZrP9 34 UPE	ZrP9 2	ZrP9 12	ZrP9 20C	ZrP9 20D	ZrP9 20E	ZrP9 21A	ZrP9 21B	ZrP9 21C	ZrP9 21D	ZrP9 21E	ZrP9 21F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
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Figure A36. Zirconium Covariance Matrix for 36 ANL Benchmarks.

 

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[illegible]

Figure A38. Steel Plates in Core Covariance Matrix for 36 ANL Benchmarks.

Steel in Tusks	ZPR3 6F	ZPR3 11	ZPR3 12	ZPR3 23	ZPR3 41	ZPR3 48	ZPR3 48B	ZPR3 58B	ZPR6 6A	ZPR6 7	ZPR6 7PU	ZPR6 9U9	ZPR6 10	ZPR9 1	ZPR9 2	ZPR9 3	ZPR9 4	ZPR9 5	ZPR9 6	ZPR9 7	ZPR9 8	ZPR9 9	ZPR9 31	ZPR9 34	ZPR9 Z	ZPR9 12	ZPR9 20C	ZPR9 20D	ZPR9 20E-4	ZPR9 20F-4	ZPR9 21A	ZPR9 21B	ZPR9 21C	ZPR9 21D	ZPR9 21E	ZPR9 21F	ZPR9 21G	ZPR9 21H	ZPR9 21I	ZPR9 21J	ZPR9 21K	ZPR9 21L	ZPR9 21M	ZPR9 21N	ZPR9 21O	ZPR9 21P	ZPR9 21Q	ZPR9 21R	ZPR9 21S	ZPR9 21T	ZPR9 21U	ZPR9 21V	ZPR9 21W	ZPR9 21X	ZPR9 21Y	ZPR9 21Z	ZPR9 21AA	ZPR9 21AB	ZPR9 21AC	ZPR9 21AD	ZPR9 21AE	ZPR9 21AF	ZPR9 21AG	ZPR9 21AH	ZPR9 21AI	ZPR9 21AJ	ZPR9 21AK	ZPR9 21AL	ZPR9 21AM	ZPR9 21AN	ZPR9 21AO	ZPR9 21AP	ZPR9 21AQ	ZPR9 21AR	ZPR9 21AS	ZPR9 21AT	ZPR9 21AU	ZPR9 21AV	ZPR9 21AW	ZPR9 21AX	ZPR9 21AY	ZPR9 21AZ	ZPR9 21BA	ZPR9 21BB	ZPR9 21BC	ZPR9 21BD	ZPR9 21BE	ZPR9 21BF	ZPR9 21BG	ZPR9 21BH	ZPR9 21BI	ZPR9 21BJ	ZPR9 21BK	ZPR9 21BL	ZPR9 21BM	ZPR9 21BN	ZPR9 21BO	ZPR9 21BP	ZPR9 21BQ	ZPR9 21BR	ZPR9 21BS	ZPR9 21BT	ZPR9 21BU	ZPR9 21BV	ZPR9 21BW	ZPR9 21BX	ZPR9 21BY	ZPR9 21BZ	ZPR9 21CA	ZPR9 21CB	ZPR9 21CC	ZPR9 21CD	ZPR9 21CE	ZPR9 21CF	ZPR9 21CG	ZPR9 21CH	ZPR9 21CI	ZPR9 21CJ	ZPR9 21CK	ZPR9 21CL	ZPR9 21CM	ZPR9 21CN	ZPR9 21CO	ZPR9 21CP	ZPR9 21CQ	ZPR9 21CR	ZPR9 21CS	ZPR9 21CT	ZPR9 21CU	ZPR9 21CV	ZPR9 21CW	ZPR9 21CX	ZPR9 21CY	ZPR9 21CZ	ZPR9 21DA	ZPR9 21DB	ZPR9 21DC	ZPR9 21DD	ZPR9 21DE	ZPR9 21DF	ZPR9 21DG	ZPR9 21DH	ZPR9 21DI	ZPR9 21DJ	ZPR9 21DK	ZPR9 21DL	ZPR9 21DM	ZPR9 21DN	ZPR9 21DO	ZPR9 21DP	ZPR9 21DQ	ZPR9 21DR	ZPR9 21DS	ZPR9 21DT	ZPR9 21DU	ZPR9 21DV	ZPR9 21DW	ZPR9 21DX	ZPR9 21DY	ZPR9 21DZ	ZPR9 21EA	ZPR9 21EB	ZPR9 21EC	ZPR9 21ED	ZPR9 21EE	ZPR9 21EF	ZPR9 21EG	ZPR9 21EH	ZPR9 21EI	ZPR9 21EJ	ZPR9 21EK	ZPR9 21EL	ZPR9 21EM	ZPR9 21EN	ZPR9 21EO	ZPR9 21EP	ZPR9 21EQ	ZPR9 21ER	ZPR9 21ES	ZPR9 21ET	ZPR9 21EU	ZPR9 21EV	ZPR9 21EW	ZPR9 21EX	ZPR9 21EY	ZPR9 21EZ	ZPR9 21FA	ZPR9 21FB	ZPR9 21FC	ZPR9 21FD	ZPR9 21FE	ZPR9 21FF	ZPR9 21FG	ZPR9 21FH	ZPR9 21FI	ZPR9 21FJ	ZPR9 21FK	ZPR9 21FL	ZPR9 21FM	ZPR9 21FN	ZPR9 21FO	ZPR9 21FP	ZPR9 21FQ	ZPR9 21FR	ZPR9 21FS	ZPR9 21FT	ZPR9 21FU	ZPR9 21FV	ZPR9 21FW	ZPR9 21FX	ZPR9 21FY	ZPR9 21FZ	ZPR9 21GA	ZPR9 21GB	ZPR9 21GC	ZPR9 21GD	ZPR9 21GE	ZPR9 21GF	ZPR9 21GG	ZPR9 21GH	ZPR9 21GI	ZPR9 21GJ	ZPR9 21GK	ZPR9 21GL	ZPR9 21GM	ZPR9 21GN	ZPR9 21GO	ZPR9 21GP	ZPR9 21GQ	ZPR9 21GR	ZPR9 21GS	ZPR9 21GT	ZPR9 21GU	ZPR9 21GV	ZPR9 21GW	ZPR9 21GX	ZPR9 21GY	ZPR9 21GZ	ZPR9 21HA	ZPR9 21HB	ZPR9 21HC	ZPR9 21HD	ZPR9 21HE	ZPR9 21HF	ZPR9 21HG	ZPR9 21HH	ZPR9 21HI	ZPR9 21HJ	ZPR9 21HK	ZPR9 21HL	ZPR9 21HM	ZPR9 21HN	ZPR9 21HO	ZPR9 21HP	ZPR9 21HQ	ZPR9 21HR	ZPR9 21HS	ZPR9 21HT	ZPR9 21HU	ZPR9 21HV	ZPR9 21HW	ZPR9 21HX	ZPR9 21HY	ZPR9 21HZ	ZPR9 21IA	ZPR9 21IB	ZPR9 21IC	ZPR9 21ID	ZPR9 21IE	ZPR9 21IF	ZPR9 21IG	ZPR9 21IH	ZPR9 21II	ZPR9 21IJ	ZPR9 21IK	ZPR9 21IL	ZPR9 21IM	ZPR9 21IN	ZPR9 21IO	ZPR9 21IP	ZPR9 21IQ	ZPR9 21IR	ZPR9 21IS	ZPR9 21IT	ZPR9 21IU	ZPR9 21IV	ZPR9 21IW	ZPR9 21IX	ZPR9 21IY	ZPR9 21IZ	ZPR9 21JA	ZPR9 21JB	ZPR9 21JC	ZPR9 21JD	ZPR9 21JE	ZPR9 21JF	ZPR9 21JG	ZPR9 21JH	ZPR9 21JI	ZPR9 21JJ	ZPR9 21JK	ZPR9 21JL	ZPR9 21JM	ZPR9 21JN	ZPR9 21JO	ZPR9 21JP	ZPR9 21JQ	ZPR9 21JR	ZPR9 21JS	ZPR9 21JT	ZPR9 21JU	ZPR9 21JV	ZPR9 21JW	ZPR9 21JX	ZPR9 21JY	ZPR9 21JZ	ZPR9 21KA	ZPR9 21KB	ZPR9 21KC	ZPR9 21KD	ZPR9 21KE	ZPR9 21KF	ZPR9 21KG	ZPR9 21KH	ZPR9 21KI	ZPR9 21KJ	ZPR9 21KL	ZPR9 21KM	ZPR9 21KN	ZPR9 21KO	ZPR9 21KP	ZPR9 21KQ	ZPR9 21KR	ZPR9 21KS	ZPR9 21KT	ZPR9 21KU	ZPR9 21KV	ZPR9 21KW	ZPR9 21KX	ZPR9 21KY	ZPR9 21KZ	ZPR9 21LA	ZPR9 21LB	ZPR9 21LC	ZPR9 21LD	ZPR9 21LE	ZPR9 21LF	ZPR9 21LG	ZPR9 21LH	ZPR9 21LI	ZPR9 21LJ	ZPR9 21LK	ZPR9 21LL	ZPR9 21LM	ZPR9 21LN	ZPR9 21LO	ZPR9 21LP	ZPR9 21LQ	ZPR9 21LR	ZPR9 21LS	ZPR9 21LT	ZPR9 21LU	ZPR9 21LV	ZPR9 21LW	ZPR9 21LX	ZPR9 21LY	ZPR9 21LZ	ZPR9 21MA	ZPR9 21MB	ZPR9 21MC	ZPR9 21MD	ZPR9 21ME	ZPR9 21MF	ZPR9 21MG	ZPR9 21MH	ZPR9 21MI	ZPR9 21MJ	ZPR9 21MK	ZPR9 21ML	ZPR9 21MN	ZPR9 21MO	ZPR9 21MP	ZPR9 21MQ	ZPR9 21MR	ZPR9 21MS	ZPR9 21MT	ZPR9 21MU	ZPR9 21MV	ZPR9 21MW	ZPR9 21MX	ZPR9 21MY	ZPR9 21MZ	ZPR9 21NA	ZPR9 21NB	ZPR9 21NC	ZPR9 21ND	ZPR9 21NE	ZPR9 21NF	ZPR9 21NG	ZPR9 21NH	ZPR9 21NI	ZPR9 21NJ	ZPR9 21NK	ZPR9 21NL	ZPR9 21NM	ZPR9 21NO	ZPR9 21NP	ZPR9 21NQ	ZPR9 21NR	ZPR9 21NS	ZPR9 21NT	ZPR9 21NU	ZPR9 21NV	ZPR9 21NW	ZPR9 21NX	ZPR9 21NY	ZPR9 21NZ	ZPR9 21OA	ZPR9 21OB	ZPR9 21OC	ZPR9 21OD	ZPR9 21OE	ZPR9 21OF	ZPR9 21OG	ZPR9 21OH	ZPR9 21OI	ZPR9 21OJ	ZPR9 21OK	ZPR9 21OL	ZPR9 21OM	ZPR9 21ON	ZPR9 21OO	ZPR9 21OP	ZPR9 21OQ	ZPR9 21OR	ZPR9 21OS	ZPR9 21OT	ZPR9 21OU	ZPR9 21OV	ZPR9 21OW	ZPR9 21OX	ZPR9 21OY	ZPR9 21OZ	ZPR9 21PA	ZPR9 21PB	ZPR9 21PC	ZPR9 21PD	ZPR9 21PE	ZPR9 21PF	ZPR9 21PG	ZPR9 21PH	ZPR9 21PI	ZPR9 21PJ	ZPR9 21PK	ZPR9 21PL	ZPR9 21PM	ZPR9 21PN	ZPR9 21PO	ZPR9 21PP	ZPR9 21PQ	ZPR9 21PR	ZPR9 21PS	ZPR9 21PT	ZPR9 21PU	ZPR9 21PV	ZPR9 21PW	ZPR9 21PX	ZPR9 21PY	ZPR9 21PZ	ZPR9 21QA	ZPR9 21QB	ZPR9 21QC	ZPR9 21QD	ZPR9 21QE	ZPR9 21QF	ZPR9 21QG	ZPR9 21QH	ZPR9 21QI	ZPR9 21QJ	ZPR9 21QK	ZPR9 21QL	ZPR9 21QM	ZPR9 21QN	ZPR9 21QO	ZPR9 21QP	ZPR9 21QQ	ZPR9 21QR	ZPR9 21QS	ZPR9 21QT	ZPR9 21QU	ZPR9 21QV	ZPR9 21QW	ZPR9 21QX	ZPR9 21QY	ZPR9 21QZ	ZPR9 21RA	ZPR9 21RB	ZPR9 21RC	ZPR9 21RD	ZPR9 21RE	ZPR9 21RF	ZPR9 21RG	ZPR9 21RH	ZPR9 21RI	ZPR9 21RJ	ZPR9 21RK	ZPR9 21RL	ZPR9 21RM	ZPR9 21RN	ZPR9 21RO	ZPR9 21RP	ZPR9 21RQ	ZPR9 21RR	ZPR9 21RS	ZPR9 21RT	ZPR9 21RU	ZPR9 21RV	ZPR9 21RW	ZPR9 21RX	ZPR9 21RY	ZPR9 21RZ	ZPR9 21SA	ZPR9 21SB	ZPR9 21SC	ZPR9 21SD	ZPR9 21SE	ZPR9 21SF	ZPR9 21SG	ZPR9 21SH	ZPR9 21SI	ZPR9 21SJ	ZPR9 21SK	ZPR9 21SL	ZPR9 21SM	ZPR9 21SN	ZPR9 21SO	ZPR9 21SP	ZPR9 21SQ	ZPR9 21SR	ZPR9 21SS	ZPR9 21ST	ZPR9 21SU	ZPR9 21SV	ZPR9 21SW	ZPR9 21SX	ZPR9 21SY	ZPR9 21SZ	ZPR9 21TA	ZPR9 21TB	ZPR9 21TC	ZPR9 21TD	ZPR9 21TE	ZPR9 21TF	ZPR9 21TG	ZPR9 21TH	ZPR9 21TI	ZPR9 21TJ	ZPR9 21TK	ZPR9 21TL	ZPR9 21TM	ZPR9 21TN	ZPR9 21TO	ZPR9 21TP	ZPR9 21TQ	ZPR9 21TR	ZPR9 21TS	ZPR9 21TT	ZPR9 21TU	ZPR9 21TV	ZPR9 21TW	ZPR9 21TX	ZPR9 21TY	ZPR9 21TZ	ZPR9 21UA	ZPR9 21UB	ZPR9 21UC	ZPR9 21UD	ZPR9 21UE	ZPR9 21UF	ZPR9 21UG	ZPR9 21UH	ZPR9 21UI	ZPR9 21UJ	ZPR9 21UK	ZPR9 21UL	ZPR9 21UM	ZPR9 21UN	ZPR9 21UO	ZPR9 21UP	ZPR9 21UQ	ZPR9 21UR	ZPR9 21US	ZPR9 21UT	ZPR9 21UU	ZPR9 21UV	ZPR9 21UW	ZPR9 21UX	ZPR9 21UY	ZPR9 21UZ	ZPR9 21VA	ZPR9 21VB	ZPR9 21VC	ZPR9 21VD	ZPR9 21VE	ZPR9 21VF	ZPR9 21VG	ZPR9 21VH	ZPR9 21VI	ZPR9 21VJ	ZPR9 21VK	ZPR9 21VL	ZPR9 21VM	ZPR9 21VN	ZPR9 21VO	ZPR9 21VP	ZPR9 21VQ	ZPR9 21VR	ZPR9 21VS	ZPR9 21VT	ZPR9 21VU	ZPR9 21VV	ZPR9 21VW	ZPR9 21VX	ZPR9 21VY	ZPR9 21VZ	ZPR9 21WA	ZPR9 21WB	ZPR9 21WC	ZPR9 21WD	ZPR9 21WE	ZPR9 21WF	ZPR9 21WG	ZPR9 21WH	ZPR9 21WI	ZPR9 21WJ	ZPR9 21WK	ZPR9 21WL	ZPR9 21WM	ZPR9 21WN	ZPR9 21WO	ZPR9 21WP	ZPR9 21WQ	ZPR9 21WR	ZPR9 21WS	ZPR9 21WT	ZPR9 21WU	ZPR9 21WV	ZPR9 21WW	ZPR9 21WX	ZPR9 21WY	ZPR9 21WZ	ZPR9 21XA	ZPR9 21XB	ZPR9 21XC	ZPR9 21XD	ZPR9 21XE	ZPR9 21XF	ZPR9 21XG	ZPR9 21XH	ZPR9 21XI	ZPR9 21XJ	ZPR9 21XK	ZPR9 21XL	ZPR9 21XM	ZPR9 21XN	ZPR9 21XO	ZPR9 21XP	ZPR9 21XQ	ZPR9 21XR	ZPR9 21XS	ZPR9 21XT	ZPR9 21XU	ZPR9 21XV	ZPR9 21XW	ZPR9 21XX	ZPR9 21XY	ZPR9 21XZ	ZPR9 21YA	ZPR9 21YB	ZPR9 21YC	ZPR9 21YD	ZPR9 21YE	ZPR9 21YF	ZPR9 21YG	ZPR9 21YH	ZPR9 21YI	ZPR9 21YJ	ZPR9 21YK	ZPR9 21YL	ZPR9 21YM	ZPR9 21YN	ZPR9 21YO	ZPR9 21YP	ZPR9 21YQ	ZPR9 21YR	ZPR9 21YS	ZPR9 21YT	ZPR9 21YU	ZPR9 21YV	ZPR9 21YW	ZPR9 21YX	ZPR9 21YY	ZPR9 21YZ	ZPR9 21ZA	ZPR9 21ZB	ZPR9 21ZC	ZPR9 21ZD	ZPR9 21ZE	ZPR9 21ZF	ZPR9 21ZG	ZPR9 21ZH	ZPR9 21ZI	ZPR9 21ZJ	ZPR9 21ZK	ZPR9 21ZL	ZPR9 21ZM	ZPR9 21ZN	ZPR9 21ZO	ZPR9 21ZP	ZPR9 21ZQ	ZPR9 21ZR	ZPR9 21ZS	ZPR9 21ZT	ZPR9 21ZU	ZPR9 21ZV	ZPR9 21ZW	ZPR9 21ZX	ZPR9 21ZY	ZPR9 21ZZ	ZPR9 21AA	ZPR9 21AB	ZPR9 21AC	ZPR9 21AD	ZPR9 21AE	ZPR9 21AF	ZPR9 21AG	ZPR9 21AH	ZPR9 21AI	ZPR9 21AJ	ZPR9 21AK	ZPR9 21AL	ZPR9 21AM	ZPR9 21AN	ZPR9 21AO	ZPR9 21AP	ZPR9 21AQ	ZPR9 21AR	ZPR9 21AS	ZPR9 21AT	ZPR9 21AU	ZPR9 21AV	ZPR9 21AW	ZPR9 21AX	ZPR9 21AY	ZPR9 21AZ	ZPR9 21BA	ZPR9 21BB	ZPR9 21BC	ZPR9 21BD	ZPR9 21BE	ZPR9 21BF	ZPR9 21BG	ZPR9 21BH	ZPR9 21BI	ZPR9 21BJ	ZPR9 21BK	ZPR9 21BL	ZPR9
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Figure A41. Steel in the Matrix Tubes Covariance Matrix for 36 ANL Benchmarks.

Figure A45. Enriched Uranium Covariance Matrix for 36 ANL Benchmarks.

[illegible]

Figure A46. Depleted Uranium in the Pu-U-Mo Plates Covariance Matrix for 36 ANL Benchmarks.

Depleted Uranium in Core	ZPR3 6F	ZPR3 11	ZPR3 12	ZPR3 23	ZPR3 41	ZPR3 48	ZPR3 56B	ZPR6 6A	ZPR6 7	ZPR6 9U9	ZPR6 10	ZPR9 1	ZPR9 2	ZPR9 3	ZPR9 3	ZPR9 4	ZPR9 5	ZPR9 6	ZPR9 7	ZPR9 8	ZPR9 9	ZPR9 31	ZPR9 34 LIFE	ZPR9 2	ZPR9 12	ZPR9 20C	ZPR9 20D	ZPR9 20E	ZPR9 21A	ZPR9 21B	ZPR9 21C	ZPR9 21D	ZPR9 21E	ZPR9 21F
ZPR3 6F	0.22	0.25	0.27	0.00	0.12	0.17	0.11	0.00	0.12	0.00	0.00	0.00	0.02	0.13	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
ZPR3 11	0.35	0.54	0.42	0.00	0.16	0.27	0.27	0.00	0.16	0.00	0.57	0.00	0.03	0.20	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.03	0.03
ZPR3 12	0.27	0.42	0.35	0.00	0.15	0.21	0.21	0.00	0.14	0.00	0.44	0.00	0.02	0.19	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.02
ZPR3 23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ZPR3 41	0.13	0.19	0.15	0.00	0.07	0.10	0.10	0.07	0.00	0.20	0.00	0.01	0.07	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
ZPR3 48	0.17	0.27	0.21	0.00	0.10	0.13	0.12	0.00	0.00	0.20	0.00	0.01	0.10	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
ZPR3 48B	0.17	0.27	0.21	0.00	0.10	0.13	0.12	0.00	0.00	0.20	0.00	0.01	0.10	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
ZPR3 56B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ZPR6 6A	0.12	0.18	0.14	0.00	0.07	0.09	0.09	0.00	0.00	0.00	0.00	0.01	0.07	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
ZPR6 7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ZPR6 7Pu	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ZPR6 9U9	0.20	0.30	0.25	0.00	0.10	0.15	0.15	0.00	0.10	0.00	0.59	0.00	0.21	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ZPR6 10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ZPR9 1	0.02	0.03	0.02	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.03	0.00	0.07	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
ZPR9 2	0.13	0.19	0.15	0.00	0.07	0.10	0.10	0.07	0.00	0.21	0.00	0.00	0.07	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
ZPR9 3	0.10	0.15	0.12	0.00	0.05	0.07	0.07	0.00	0.05	0.00	0.10	0.00	0.01	0.08	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
ZPR9 4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ZPR9 5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ZPR9 6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ZPR9 7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ZPR9 8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ZPR9 9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ZPR9 10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ZPR9 11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ZPR9 12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ZPR9 20C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ZPR9 20D	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ZPR9 20E	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ZPR9 21A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ZPR9 21B	0.01	0.02	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.02	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ZPR9 21C	0.01	0.02	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.02	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ZPR9 21D	0.01	0.02	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.02	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ZPR9 21E	0.01	0.02	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.02	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ZPR9 21F	0.02	0.03	0.02	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.03	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

0.00 - 0.05
0.05 - 0.10
0.10 - 0.15
0.15 - 0.20
0.20 - 0.25
0.25 - 0.30
0.30 - 0.35
0.35 - 0.40
0.40 - 0.45
0.45 - 0.50
0.50 - 0.55
0.55 - 0.60
0.60 - 0.65
0.65 - 0.70
0.70 - 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00

Figure A47. Depleted Uranium in the Core Covariance Matrix for 36 ANL Benchmarks.

0.70 - 0.75	0.80 - 0.85	0.70 - 0.80	0.75 - 0.78	0.65 - 0.70	0.60 - 0.65	0.65 - 0.60	0.50 - 0.55	0.45 - 0.50	0.40 - 0.45	0.35 - 0.40	0.30 - 0.35	0.20 - 0.25	0.15 - 0.20	0.05 - 0.10	0.0 - 0.05
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64

0.90 - 0.95	0.80 - 0.85	0.70 - 0.75	0.60 - 0.65	0.50 - 0.55	0.45 - 0.50	0.40 - 0.45	0.30 - 0.35	0.20 - 0.25	0.10 - 0.15	0.05 - 0.10	0.0 - 0.05
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Figure A50. Depleted Uranium in the Shield Covariance Matrix for 36 ANL Benchmarks.

[illegible]

99

[illegible]

Figure A52. Plutonium Covariance Matrix for 36 ANL Benchmarks.

[illegible]

Figure A53. PSR Blades Covariance Matrix for 36 ANL Benchmarks.

[illegible]

Figure A55. Polyethylene in Core Covariance Matrix for 36 ANL Benchmarks.

[illegible]

71

Borehole ID	ZPR3 6F	ZPR3 11	ZPR3 12	ZPR3 23	ZPR3 41	ZPR3 48	ZPR3 58B	ZPR6 6A	ZPR6 7	ZPR6 7PU	ZPR6 9U9	ZPR6 10	ZPR9 1	ZPR9 2	ZPR9 3	ZPR9 4	ZPR9 5	ZPR9 6	ZPR9 7	ZPR9 8	ZPR9 9	ZPR9 34	ZPR9 31	ZPR9 2	ZPR9 12	ZPR9 20C	ZPR9 20D	ZPR9 20E	ZPR9 21A	ZPR9 21B	ZPR9 21C	ZPR9 21D	ZPR9 21E	ZPR9 21F	ZPR9 21G	ZPR9 21H	ZPR9 21I	ZPR9 21J	ZPR9 21K	ZPR9 21L	ZPR9 21M	ZPR9 21N	ZPR9 21O	ZPR9 21P	ZPR9 21Q	ZPR9 21R	ZPR9 21S	ZPR9 21T	ZPR9 21U	ZPR9 21V	ZPR9 21W	ZPR9 21X	ZPR9 21Y	ZPR9 21Z	ZPR9 21AA	ZPR9 21AB	ZPR9 21AC	ZPR9 21AD	ZPR9 21AE	ZPR9 21AF	ZPR9 21AG	ZPR9 21AH	ZPR9 21AI	ZPR9 21AJ	ZPR9 21AK	ZPR9 21AL	ZPR9 21AM	ZPR9 21AN	ZPR9 21AO	ZPR9 21AP	ZPR9 21AQ	ZPR9 21AR	ZPR9 21AS	ZPR9 21AT	ZPR9 21AU	ZPR9 21AV	ZPR9 21AW	ZPR9 21AX	ZPR9 21AY	ZPR9 21AZ	ZPR9 21BA	ZPR9 21BB	ZPR9 21BC	ZPR9 21BD	ZPR9 21BE	ZPR9 21BF	ZPR9 21BG	ZPR9 21BH	ZPR9 21BI	ZPR9 21BJ	ZPR9 21BK	ZPR9 21BL	ZPR9 21BM	ZPR9 21BN	ZPR9 21BO	ZPR9 21BP	ZPR9 21BQ	ZPR9 21BR	ZPR9 21BS	ZPR9 21BT	ZPR9 21BU	ZPR9 21BV	ZPR9 21BW	ZPR9 21BX	ZPR9 21BY	ZPR9 21BZ	ZPR9 21CA	ZPR9 21CB	ZPR9 21CC	ZPR9 21CD	ZPR9 21CE	ZPR9 21CF	ZPR9 21CG	ZPR9 21CH	ZPR9 21CI	ZPR9 21CJ	ZPR9 21CK	ZPR9 21CL	ZPR9 21CM	ZPR9 21CN	ZPR9 21CO	ZPR9 21CP	ZPR9 21CQ	ZPR9 21CR	ZPR9 21CS	ZPR9 21CT	ZPR9 21CU	ZPR9 21CV	ZPR9 21CW	ZPR9 21CX	ZPR9 21CY	ZPR9 21CZ	ZPR9 21DA	ZPR9 21DB	ZPR9 21DC	ZPR9 21DD	ZPR9 21DE	ZPR9 21DF	ZPR9 21DG	ZPR9 21DH	ZPR9 21DI	ZPR9 21DJ	ZPR9 21DK	ZPR9 21DL	ZPR9 21DM	ZPR9 21DN	ZPR9 21DO	ZPR9 21DP	ZPR9 21DQ	ZPR9 21DR	ZPR9 21DS	ZPR9 21DT	ZPR9 21DU	ZPR9 21DV	ZPR9 21DW	ZPR9 21DX	ZPR9 21DY	ZPR9 21DZ	ZPR9 21EA	ZPR9 21EB	ZPR9 21EC	ZPR9 21ED	ZPR9 21EE	ZPR9 21EF	ZPR9 21EG	ZPR9 21EH	ZPR9 21EI	ZPR9 21EJ	ZPR9 21EK	ZPR9 21EL	ZPR9 21EM	ZPR9 21EN	ZPR9 21EO	ZPR9 21EP	ZPR9 21EQ	ZPR9 21ER	ZPR9 21ES	ZPR9 21ET	ZPR9 21EU	ZPR9 21EV	ZPR9 21EW	ZPR9 21EX	ZPR9 21EY	ZPR9 21EZ	ZPR9 21FA	ZPR9 21FB	ZPR9 21FC	ZPR9 21FD	ZPR9 21FE	ZPR9 21FF	ZPR9 21FG	ZPR9 21FH	ZPR9 21FI	ZPR9 21FJ	ZPR9 21FK	ZPR9 21FL	ZPR9 21FM	ZPR9 21FN	ZPR9 21FO	ZPR9 21FP	ZPR9 21FQ	ZPR9 21FR	ZPR9 21FS	ZPR9 21FT	ZPR9 21FU	ZPR9 21FV	ZPR9 21FW	ZPR9 21FX	ZPR9 21FY	ZPR9 21FZ	ZPR9 21GA	ZPR9 21GB	ZPR9 21GC	ZPR9 21GD	ZPR9 21GE	ZPR9 21GF	ZPR9 21GG	ZPR9 21GH	ZPR9 21GI	ZPR9 21GJ	ZPR9 21GK	ZPR9 21GL	ZPR9 21GM	ZPR9 21GN	ZPR9 21GO	ZPR9 21GP	ZPR9 21GQ	ZPR9 21GR	ZPR9 21GS	ZPR9 21GT	ZPR9 21GU	ZPR9 21GV	ZPR9 21GW	ZPR9 21GX	ZPR9 21GY	ZPR9 21GZ	ZPR9 21HA	ZPR9 21HB	ZPR9 21HC	ZPR9 21HD	ZPR9 21HE	ZPR9 21HF	ZPR9 21HG	ZPR9 21HH	ZPR9 21HI	ZPR9 21HJ	ZPR9 21HK	ZPR9 21HL	ZPR9 21HM	ZPR9 21HN	ZPR9 21HO	ZPR9 21HP	ZPR9 21HQ	ZPR9 21HR	ZPR9 21HS	ZPR9 21HT</
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Figure A57. Borated Polyethylene in Shield Covariance Matrix for 36 ANL Benchmarks.

Figure A59. Kel-F on Core Depleted Uranium (DU) Fuel Covariance Matrix for 36 ANL Benchmarks.

[illegible]

Figure A60. Kel-F on Core BeO Plates Covariance Matrix for 36 ANL Benchmarks.

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