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Revisiting MCNP Surface-Source Write & Read Primers

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Overview of Model & Computational Process

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Background and Motivation

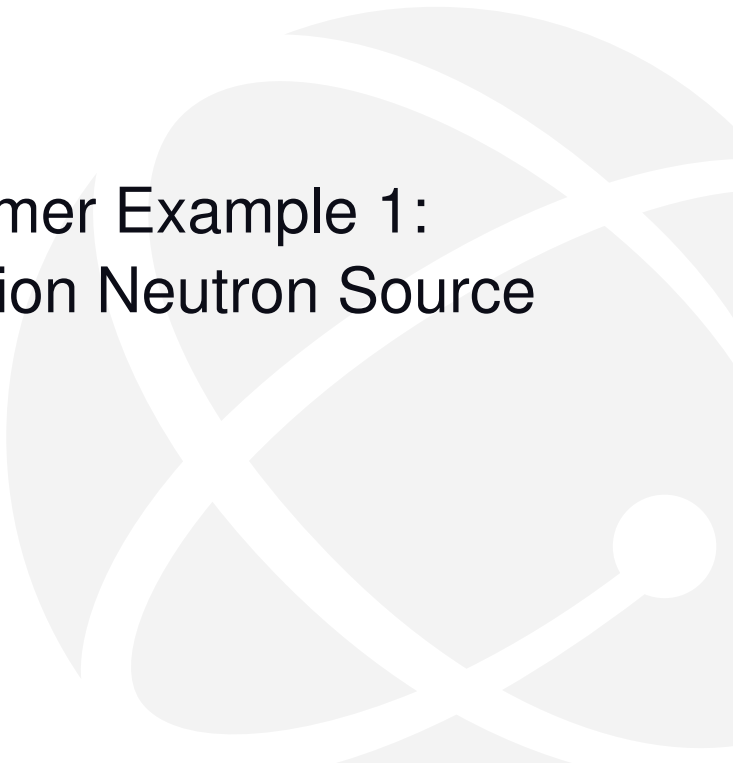
Objective

Clarify how weight evolves in “typical” MCNP “surface-source” calculations.

- ▶ SSW/SSR originally designed for surface-bootstrapped calculations
 - ▶ Run an earlier, more computationally expensive calculation, once
 - ▶ Run later, less expensive, calculations potentially many times
 - ▶ Aside: bootstrapping has been a long-standing soft spot for the author [3]
- ▶ Extended to fission-source coupling to a fixed-source calculation
 - ▶ Permits fixed-source calculations based on a converged fission-source term
- ▶ Perennial questions/confusion about this capability
 - ▶ Perhaps exacerbated by the clarity of MCNP output (say it ain't so!)
 - ▶ Challenging when sampling more or fewer source points than in the `rssa` file

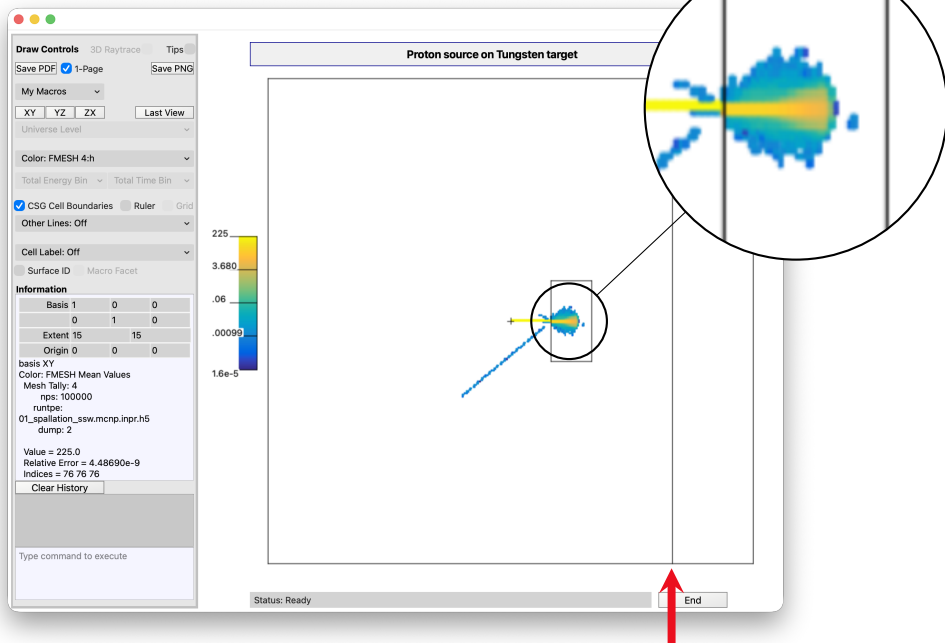
A (Brief) Review of Statistical Weight

- ▶ The MCNP code is sampling phase space with computational particles
- ▶ Each source particle represents one random walk from start to finish
 - ▶ One realization of reality
 - ▶ Includes the source particle itself, and any progeny
- ▶ The statistical weight represents the source intensity
 - ▶ ...in whatever units make sense
 - ▶ A source rate (#/time) gives rate-based results, e.g., fluence rate, dose rate
 - ▶ Radioactivity material source emission rate in decays per second
 - ▶ Be aware of time-unit conversion, e.g., source per second, tally per hour
 - ▶ A source emission (#) gives time-integrated results, e.g., fluence, dose
 - ▶ Accelerator pulse (number of protons)
 - ▶ Supercritical excursion (number of fissions → number of neutrons)
 - ▶ Entirely unrelated to number of samples (i.e., histories a.k.a. nps)
 - ▶ *Unless working with surface sources...*

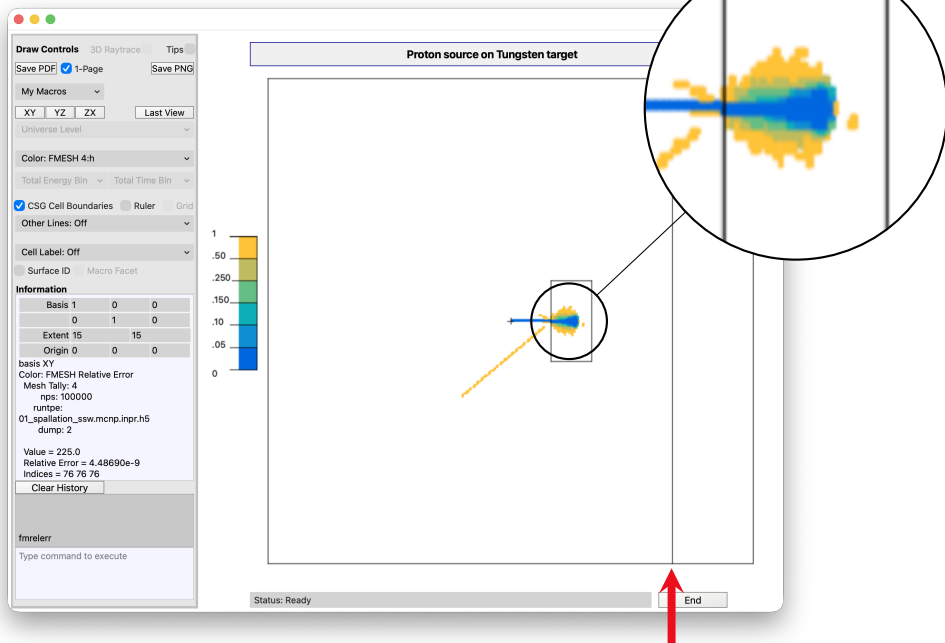


Primer Example 1: Spallation Neutron Source

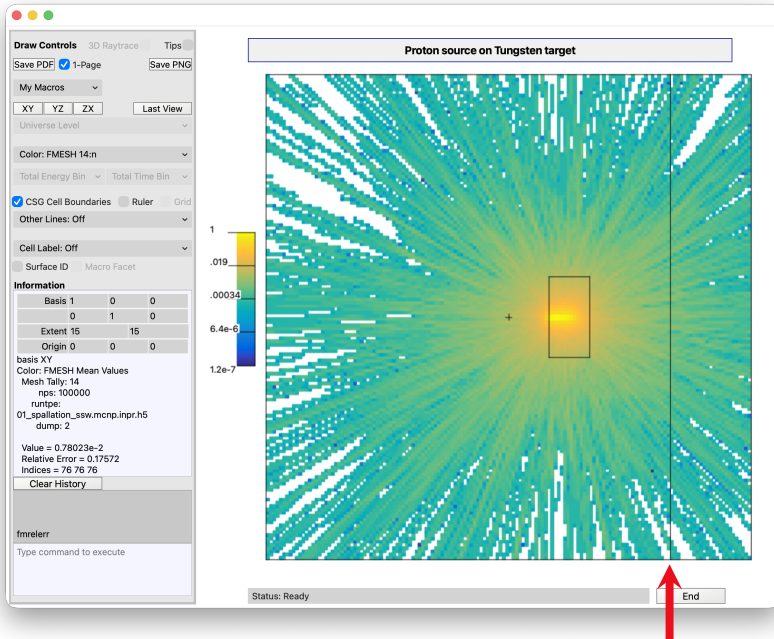
Overview of Model & Computational Process



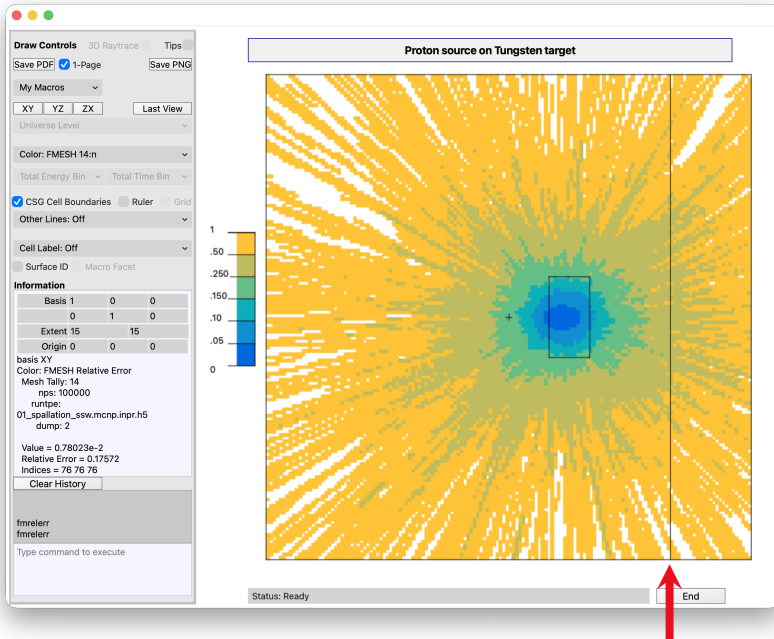
Overview of Model & Computational Process



Overview of Model & Computational Process

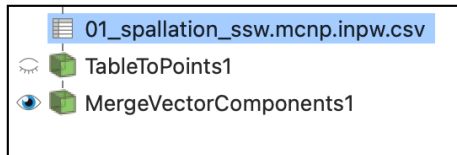


Overview of Model & Computational Process



(Neutron) Tracks Written on Surface 1

1 surface-source file 01_spallation_ssw.mcnp.inpw with
2 nps = 100000 and 23829 tracks was written for
3 surface(s) 1
4 run terminated when 100000 particle histories were done.

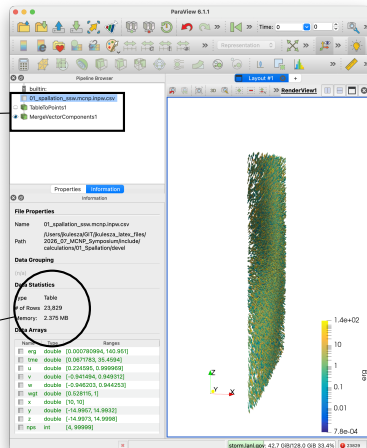


Data Statistics

Type	Table
# of Rows	23,829
Memory:	2.375 MB

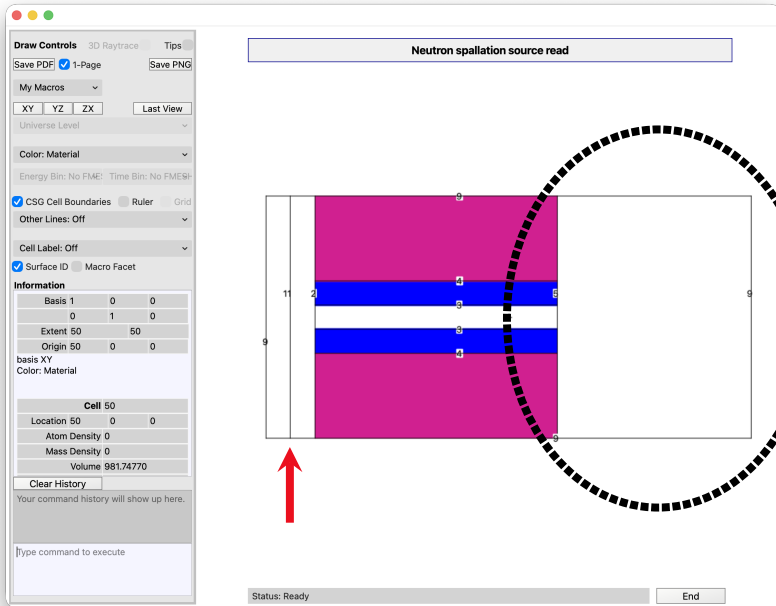
Data Arrays

Type	
------	--

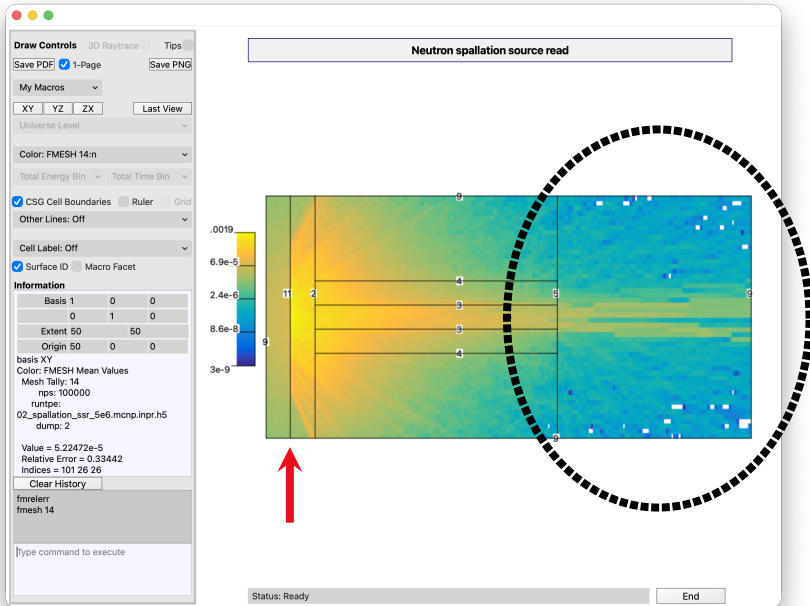


Glyph-based 3-D view using [4].

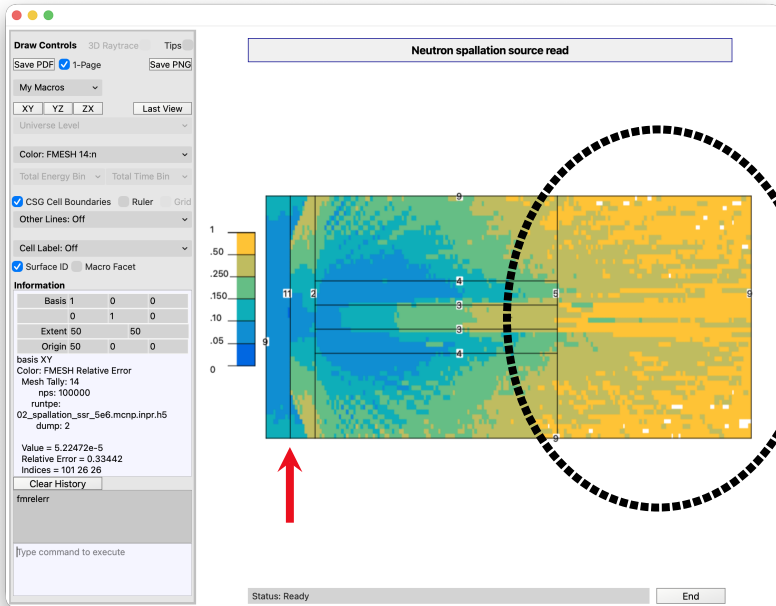
Neutron Calculation



Neutron Calculation



Neutron Calculation



Tally Versus Sampling

Listing 1: 10,000 Histories

	tally					
	nps	mean	error	vov	slope	fom
1000	2.8781E-07	0.9999	0.9994	0.0	4541	
2000	4.0099E-07	0.5869	0.3719	0.0	6636	
3000	4.5331E-07	0.5342	0.3940	0.0	5456	
4000	6.4483E-07	0.4433	0.2740	0.0	5797	
5000	7.6691E-07	0.3602	0.1893	0.0	6619	
6000	7.1972E-07	0.3401	0.1687	0.0	6583	
7000	6.1494E-07	0.3401	0.1687	0.0	5683	
8000	5.3562E-07	0.3401	0.1688	0.0	5034	
9000	5.5655E-07	0.3253	0.1488	0.0	4878	
10000	6.9338E-07	0.3269	0.2174	0.0	4524	
11000	6.3218E-07	0.3269	0.2174	0.0	4089	
12000	5.7827E-07	0.3269	0.2174	0.0	3759	
13000	5.8364E-07	0.3056	0.1900	0.0	3829	
14000	6.0499E-07	0.2884	0.1642	0.0	3997	
15000	6.5404E-07	0.2674	0.1336	0.0	4361	
16000	6.9216E-07	0.2505	0.1127	0.0	4654	
17000	6.9337E-07	0.2430	0.1027	0.0	4667	
18000	7.3266E-07	0.2299	0.0876	0.0	4895	
19569	7.3328E-07	0.2250	0.0850	0.0	4968	

Listing 2: 23,829 Histories

	tally					
	nps	mean	error	vov	slope	fom
1000	5.6758E-07	0.6380	0.6015	0.0	7690	
2000	8.8805E-07	0.3925	0.2024	0.0	10499	
3000	6.7611E-07	0.3660	0.1746	0.0	8268	
4000	7.9031E-07	0.2970	0.1068	0.0	9434	
5000	7.9998E-07	0.2624	0.0836	0.0	9867	
6000	7.5333E-07	0.2452	0.0744	0.0	9433	
7000	5.6735E-07	0.2406	0.0738	0.0	8425	
8000	5.7256E-07	0.2406	0.0738	0.0	7410	
9000	6.0931E-07	0.2224	0.0605	0.0	7749	
10000	7.1305E-07	0.2023	0.0642	0.0	8472	
11000	6.8873E-07	0.1954	0.0599	0.0	8267	
12000	6.3807E-07	0.1954	0.0599	0.0	7614	
13000	6.6941E-07	0.1820	0.0495	0.0	8135	
14000	6.9404E-07	0.1728	0.0432	0.0	8407	
15000	7.1923E-07	0.1641	0.0383	0.0	8744	
16000	7.0826E-07	0.1597	0.0360	0.0	8657	
17000	6.8351E-07	0.1577	0.0348	0.0	8380	
18000	7.0901E-07	0.1500	0.0311	0.0	8766	
19569	6.9781E-07	0.1487	0.0307	0.0	8643	

Listing 3: 5,000,000 Histories

	tally					
	nps	mean	error	vov	slope	fom
1000	8.7572E-07	0.2068	0.1510	0.0	2376	
2000	6.5998E-07	0.1464	0.1170	0.0	2482	
3000	6.3305E-07	0.1209	0.0840	3.3	2451	
4000	6.5471E-07	0.1041	0.0574	10.0	2435	
5000	6.3278E-07	0.0925	0.0502	7.7	2442	
6000	6.0696E-07	0.0833	0.0450	4.3	2509	
7000	5.9730E-07	0.0779	0.0390	4.3	2467	
8000	5.8696E-07	0.0735	0.0347	4.2	2426	
9000	6.1429E-07	0.0704	0.0278	9.0	2345	
10000	6.1743E-07	0.0662	0.0254	5.3	2400	
11000	6.2037E-07	0.0623	0.0231	5.6	2468	
12000	6.0597E-07	0.0601	0.0218	5.2	2441	
13000	6.1343E-07	0.0583	0.0194	5.9	2401	
14000	6.0926E-07	0.0562	0.0183	4.7	2392	
15000	6.1537E-07	0.0541	0.0170	4.5	2423	
16000	6.1092E-07	0.0526	0.0160	6.0	2407	
17000	6.0941E-07	0.0514	0.0149	6.7	2378	
18000	6.0844E-07	0.0501	0.0142	5.9	2360	
19569	6.1356E-07	0.0493	0.0136	6.2	2359	

Listing 4: Surface-source File Diagnostic Information in 5,000,000 History Output File

```

1 information from the header of surface-source file 01.spallation.ssw.mcnp.inpw
2
3 the file was written by mcnp6 version 6 with probid = 08/09/26 21:44:51 and ending with dump no. 2
4 the title of the creation run was Proton source on Tungsten target
5 the original number of histories was 18569
6 the total number of tracks recorded was 23829 from 18569 independent histories.
7
8 creation-run surfaces
9 surface type coefficients
10 1 1 px 1.00000E+01
11
12 this ssr problem will use the following particles if available: neutron
13
14 summary for all particles per surface or cell.
15 no. total tracks independent histories
16 1 23829 18569
17
18 neutron summary per surface or cell.
19 no. tracks indp. tracks uncollided indp. uncol.
20 1 23829 18569 9570 7863

```

Weight Normalization Versus Sampling

- ▶ 100,000 Proton Histories
- ▶ 23,829 (Neutron) Tracks Stored
- ▶ 18,569 Independent Histories
- ▶ Goal: sample 5,000,000 neutrons

$$\text{Neutron Source Weight} = \frac{\text{Proton Source Weight} \times \# \text{ Proton Histories}}{\# \text{ Neutron Histories}} \quad (1)$$

Listing 5: Print Table 110 (and Problem Summary Header) in 5,000,000 History Output File

	nps	x	y	z	cell	surf	u	v	w	energy	weight	time
1	1	5.000E+00	9.735E+00	-7.351E-01	20	11	5.026E-01	8.630E-01	-5.131E-02	9.256E+00	2.000E-02	3.039E-01
2	2	5.000E+00	5.153E-01	3.169E+00	20	11	9.117E-01	6.857E-02	4.051E-01	1.150E+00	2.000E-02	5.477E-01
3	3	5.000E+00	2.287E+00	-3.983E+00	20	11	8.989E-01	2.154E-01	-3.815E-01	8.105E-01	1.977E-02	6.796E-01
4	...											
5	47	5.000E+00	-9.443E-01	-1.342E+00	20	11	9.751E-01	-1.275E-01	-1.813E-01	1.924E+00	2.000E-02	4.042E-01
6	48	5.000E+00	-2.389E+00	-1.182E+00	20	11	9.276E-01	-3.367E-01	-1.621E-01	5.920E+00	2.000E-02	2.269E-01
7	49	5.000E+00	-8.482E+00	-1.265E+01	20	11	4.410E-01	-4.999E-01	-7.454E-01	3.985E+00	2.000E-02	6.330E-01
8	50	5.000E+00	-4.307E+00	-7.518E-01	20	11	8.088E-01	-5.879E-01	1.373E-02	5.771E-01	1.979E-02	8.719E-01
9	problem summary											
10	source particle weight for summary table normalization =											100000.00

Surface Source Acceptance/Rejection Mechanics

- ▶ Print Table 170 gives “summary information from this use of surface-source file”
- ▶ Of the total number of recorded histories:
 1. Compute ratio of sampling desired, e.g., 23,829 / 100,000
 2. Use subset of records to preserve corresponding ratio of sampling and weight
 - ▶ $10,000/100,000 = 0.1 \times 23,829 \approx 2492$ accepted records
 - ▶ $23,829/100,000 = 0.23829 \times 23,829 \approx 5692$ accepted records
 - ▶ $5,000,000/100,000 > 1 \rightarrow$ all records accepted

Listing 6: 10,000 Histories

neutron creation	tracks	weight (per source particle)	energy
source	2492	2.4705E-01	9.0388E+00
...			
number of original histories		100000	
number of records read		23829	
number of recorded histories		18569	
number of histories read		1887	
source multiplication factor		0.10000	
total source weight		2.36265E+04	
total rejected weight		0.00000E+00	
fraction weight rejected		0.00000E+00	
...			
particles rejected by nps limits		21337	
no weight loss associated with this rejection mode.			
total number of particles rejected		21337	
total number of particles accepted		2492	
total weight accepted		2.47051E+04	
fraction of total weight accepted		0.10457E+01	

Listing 7: 23,829 Histories

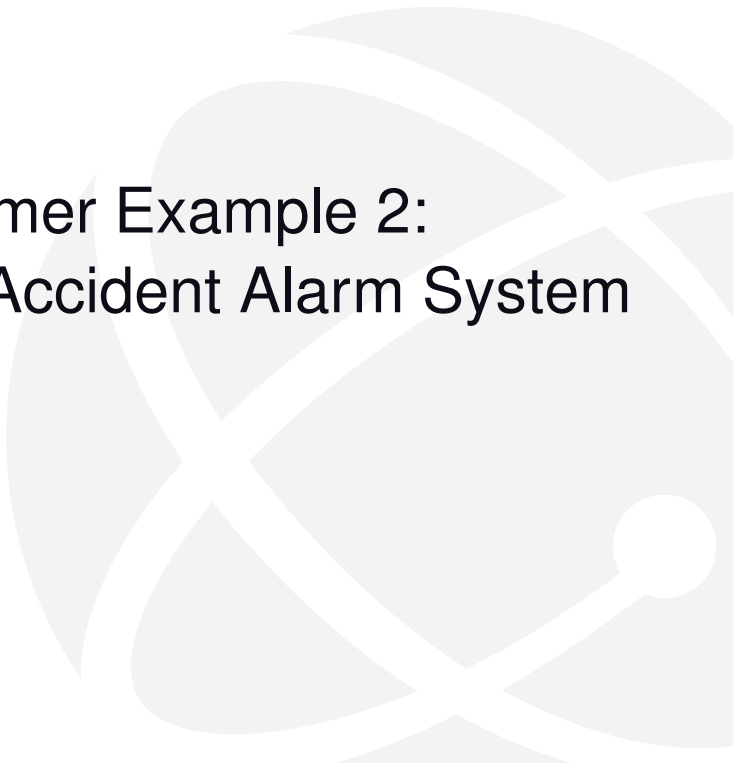
neutron creation	tracks	weight (per source particle)	energy
source	5692	2.3681E-01	9.0967E+00
...			
number of original histories		100000	
number of records read		23829	
number of recorded histories		18569	
number of histories read		4397	
source multiplication factor		0.23829	
total source weight		2.36265E+04	
total rejected weight		0.00000E+00	
fraction weight rejected		0.00000E+00	
...			
particles rejected by nps limits		18137	
no weight loss associated with this rejection mode.			
total number of particles rejected		18137	
total number of particles accepted		5692	
total weight accepted		2.36814E+04	
fraction of total weight accepted		0.10023E+01	

Listing 8: 5,000,000 Histories

neutron creation	tracks	weight (per source particle)	energy
source	1191450	2.3627E-01	9.0639E+00
...			
number of original histories		100000	
number of records read		23829	
number of recorded histories		18569	
number of histories read		18569	
source multiplication factor		50.00000	
total source weight		2.36265E+04	
total rejected weight		0.00000E+00	
fraction weight rejected		0.00000E+00	
...			
particles rejected by nps limits		0	
no weight loss associated with this rejection mode.			
total number of particles rejected		0	
total number of particles accepted		23829	
total weight accepted		2.36265E+04	
fraction of total weight accepted		0.10000E+01	

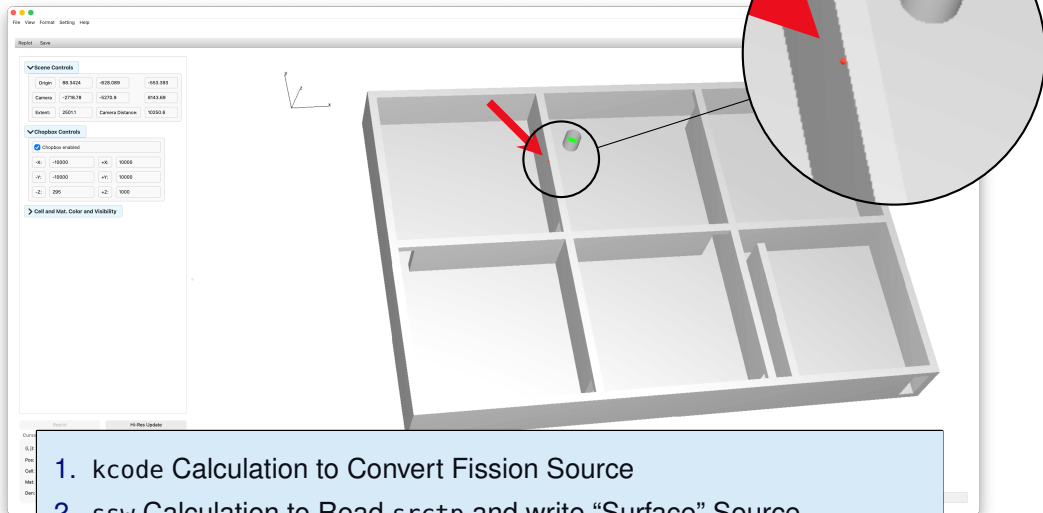
What Does It All Mean?

- ▶ Weight is being correctly preserved regardless of number of histories
- ▶ Some of the output is challenging to interpret
 - ▶ However, surface-source read calculations have diagnostics to help
- ▶ Sample!
 - ▶ Run as many histories as you can to write the surface source
 - ▶ Run as many histories as you can using the surface source
 - ▶ More of the former leads to greater independence
 - ▶ More of the latter leads to better statistics in the end
- ▶ Run equal amounts of histories in both stages to keep weight ≈ 1
 - ▶ Not necessary, but may help with variance-reduction consistency
- ▶ Vary the random number generator seed between SSW and SSR calculations
 - ▶ See the SSR card's caution box [p. 430 of [5](#)] for more information



Primer Example 2: Criticality Accident Alarm System

Overview of Model & Computational Process



1. kcode Calculation to Convert Fission Source
2. ssw Calculation to Read srctp and write "Surface" Source
3. ssr Calculation(s) to Read "Surface" Source

Overview of Model & Computational Process, cont.

1. kcode Calculation to Convert Fission Source

```
1 sdef pos = 0 0 1
2   rad = d1
3   vec = 1 0 0
4   axs = 0 0 1
5   ext = d2
6   erg = d3
7 si1 0 50
8 sp1 -21 1
9 si2 0 12.6
10 sp2 -21 0
11 sp3 -3 0.885247 3.802690 $ Pu-239 Watt: LA-UR-24-24602, Rev. 1, Listing 5.29
12 C
13 kcode 50000 1.0 50 150
14 rand gen=2 seed=12345
```

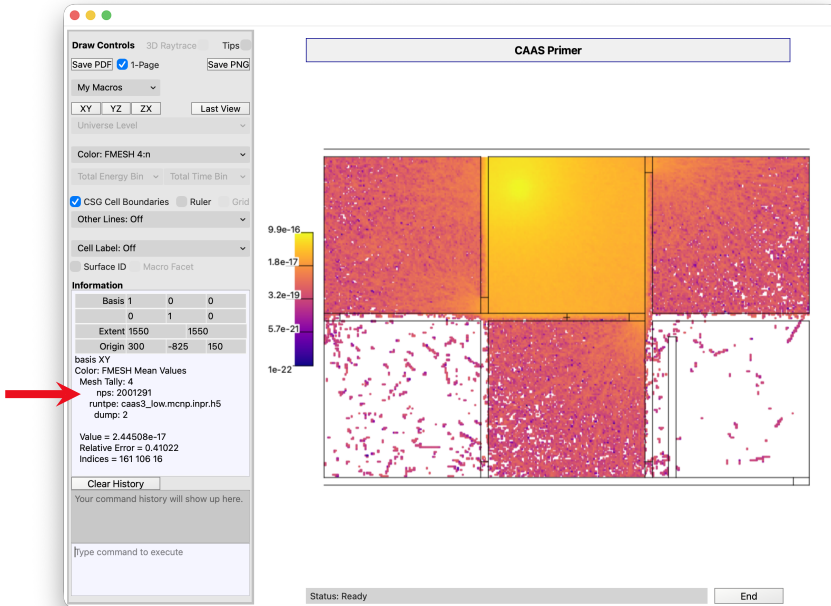
2. ssw Calculation to Read srctp and write "Surface" Source

```
1 kcode 20000 1.0 1 101
2 ssw cel = 100
3 rand gen=2 seed=1234567
```

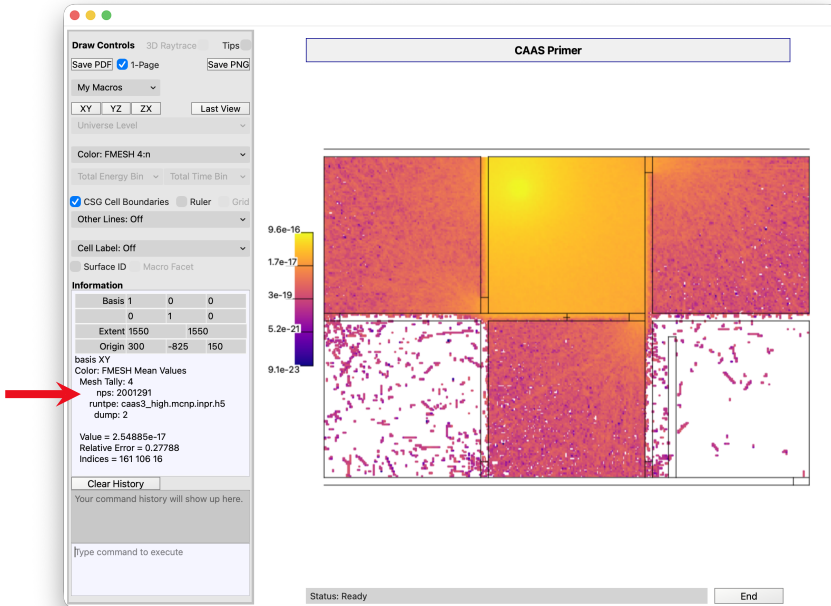
3. ssr Calculation(s) to Read "Surface" Source

```
1 nps 1.5e6
2 ssr cel = 100 wgt = 1.0 psc = 0.5
3 nonu
4 rand gen=2 seed=123456789
```

Sampling Coverage versus Results



Sampling Coverage versus Results



Results for CAAS

Listing 9: 1.5M Histories

	nps	tally			5			tally			6		
		mean	error	vov	slope	fom		mean	error	vov	slope	fom	
128000	4.9994E-21	0.2141	0.1388	1.3	58	0.0000E+00	0.0000	0.0000	0.0	0.0E+00			
256000	1.4670E-19	0.9692	0.9999	1.5	1.4E+00	1.2785E-18	1.0000	1.0000	0.0	1.3E+00			
384000	1.2493E-19	0.7838	0.8823	1.6	1.5E+00	8.5236E-19	1.0000	1.0000	0.0	9.1E-01			
512000	9.4440E-20	0.7776	0.8823	1.7	1.1E+00	6.3927E-19	1.0000	1.0000	0.0	6.9E-01			
640000	7.6447E-20	0.7685	0.8823	1.9	9.3E-01	5.1142E-19	1.0000	1.0000	0.0	5.5E-01			
768000	6.4259E-20	0.7619	0.8823	2.0	7.9E-01	4.2618E-19	1.0000	1.0000	0.0	4.6E-01			
896000	5.5621E-20	0.7544	0.8822	2.1	6.9E-01	3.6530E-19	1.0000	1.0000	0.0	3.9E-01			
1024000	5.0496E-20	0.7277	0.8797	2.1	6.4E-01	3.1963E-19	1.0000	1.0000	0.0	3.4E-01			
1152000	4.5342E-20	0.7203	0.8797	2.1	5.8E-01	2.8412E-19	1.0000	1.0000	0.0	3.0E-01			
1280000	4.2918E-20	0.6857	0.8756	2.0	5.7E-01	2.5571E-19	1.0000	1.0000	0.0	2.7E-01			
1408000	4.1100E-20	0.6522	0.8688	2.0	5.7E-01	2.3248E-19	0.9999	1.0000	0.0	2.4E-01			
1536000	3.8037E-20	0.6460	0.8687	2.0	5.3E-01	2.1311E-19	0.9999	1.0000	0.0	2.2E-01			
1664000	3.5535E-20	0.6383	0.8687	2.0	4.9E-01	1.9673E-19	0.9998	1.0000	0.0	2.0E-01			
1792000	3.3272E-20	0.6331	0.8686	2.0	4.6E-01	1.8268E-19	0.9998	1.0000	0.0	1.8E-01			
1920000	3.5780E-20	0.5563	0.8271	1.9	5.5E-01	1.8028E-19	0.9472	0.9935	0.0	1.9E-01			
2001291	3.4461E-20	0.5541	0.8271	1.9	5.3E-01	1.7296E-19	0.9472	0.9935	0.0	1.8E-01			

6.21 minutes

Listing 10: 2.5M Histories

	nps	tally			5			tally			6		
		mean	error	vov	slope	fom		mean	error	vov	slope	fom	
128000	7.2911E-21	0.2525	0.3932	1.4	23	0.0000E+00	0.0000	0.0000	0.0	0.0E+00			
256000	1.0853E-20	0.5212	0.9326	1.7	2.8E+00	0.0000E+00	0.0000	0.0000	0.0	0.0E+00			
384000	9.0815E-21	0.4202	0.8896	1.8	2.8E+00	0.0000E+00	0.0000	0.0000	0.0	0.0E+00			
512000	7.6287E-21	0.3758	0.8833	2.2	2.6E+00	0.0000E+00	0.0000	0.0000	0.0	0.0E+00			
640000	7.0291E-21	0.3279	0.8666	2.3	2.7E+00	0.0000E+00	0.0000	0.0000	0.0	0.0E+00			
768000	6.5727E-21	0.2933	0.8537	2.3	2.7E+00	3.6722E-24	1.0000	1.0000	0.0	2.4E-01			
896000	6.1647E-21	0.2690	0.8413	2.3	2.8E+00	3.1476E-24	1.0000	1.0000	0.0	2.0E-01			
1024000	7.2196E-21	0.2540	0.4321	2.1	2.7E+00	2.7542E-24	1.0000	1.0000	0.0	1.7E-01			
1152000	7.0787E-21	0.2337	0.4078	2.2	2.8E+00	2.8433E-23	0.9179	0.9826	0.0	1.8E-01			
1280000	9.4916E-21	0.2520	0.2734	2.1	2.2E+00	3.1942E-23	0.7618	0.8578	0.0	2.4E-01			
1408000	2.9568E-20	0.6715	0.9740	1.9	2.8E-01	2.9038E-23	0.7618	0.8578	0.0	2.2E-01			
1536000	2.7729E-20	0.6564	0.9738	1.9	2.6E-01	2.6619E-23	0.7618	0.8578	0.0	2.0E-01			
1664000	2.5950E-20	0.6474	0.9738	1.9	2.5E-01	3.8701E-23	0.6060	0.4798	0.0	2.9E-01			
1792000	2.4432E-20	0.6386	0.9737	1.9	2.4E-01	3.5937E-23	0.6060	0.4798	0.0	2.7E-01			
1920000	2.8378E-20	0.5348	0.8310	1.8	3.2E-01	3.3541E-23	0.6060	0.4798	0.0	2.5E-01			
2001291	2.7353E-20	0.5323	0.8310	1.8	3.1E-01	3.2179E-23	0.6060	0.4798	0.0	2.4E-01			

11.59 minutes

(FW-)CADIS Overview, and “Global” Dose Rate

Conventional Calculation

- ▶ Forward flux, $\mathbf{L}\psi = q$
- ▶ Total detector response, $D = \langle \Sigma_D, \psi \rangle$, or
- ▶ Multiple detector responses, $D_i = \langle \Sigma_D^i, \psi \rangle$

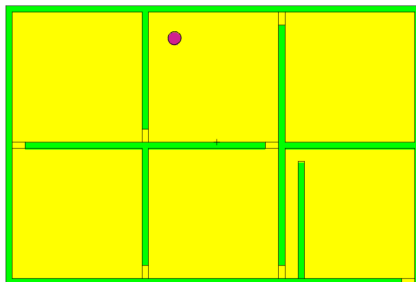
CADIS Calculation

- ▶ Adjoint source, $q^* = \Sigma_D$
- ▶ Adjoint flux, $\mathbf{L}^*\psi^* = q^*$
- ▶ Total response, $D = \langle q, \psi^* \rangle$
- ▶ Weight targets, $w = D/\psi^*$
- ▶ Biased source, $\tilde{q} = q\psi^*/D$

See [6–9]

FW-CADIS Calculation

- ▶ Forward flux, $\mathbf{L}\psi = q$
 - ▶ Adjoint source, $q^* = \sum_i \Sigma_D^i / \langle \Sigma_D^i, \psi \rangle$
- ← Use q^* in CADIS sequence



CADIS Results: Detector

Listing 11: 1.5M Histories

	nps	tally			fom		tally			fom
		mean	error	vov			mean	error	vov	
128000	1.0492E-18	0.4496	0.7598	1.4	20	1.8072E-20	0.1810	0.2044	0.0	123
256000	1.2849E-18	0.4029	0.6123	1.8	11	1.7815E-20	0.1574	0.3200	2.6	73
384000	1.4596E-18	0.3223	0.2919	2.0	11	1.6419E-20	0.1205	0.2559	2.9	81
512000	1.3167E-18	0.2772	0.2577	1.9	11	1.5852E-20	0.1015	0.1893	2.9	85
640000	1.1707E-18	0.2509	0.2517	1.9	11	1.6697E-20	0.0888	0.1146	2.8	88
768000	1.1651E-18	0.2188	0.2177	1.9	12	1.5834E-20	0.0822	0.0961	2.9	85
896000	1.3608E-18	0.1968	0.1471	1.9	12	1.5545E-20	0.0764	0.0817	2.7	82
1024000	1.4229E-18	0.1776	0.1169	1.8	13	1.5709E-20	0.0716	0.0666	2.7	80
1152000	1.3610E-18	0.1673	0.1111	1.8	13	1.5156E-20	0.0669	0.0629	2.9	81
1280000	1.2900E-18	0.1593	0.1098	1.8	13	1.4999E-20	0.0632	0.0545	3.1	81
1408000	1.3375E-18	0.1459	0.0955	1.8	14	1.4910E-20	0.0605	0.0477	3.2	79
1536000	1.3104E-18	0.1387	0.0901	1.9	14	1.5307E-20	0.0589	0.0384	3.2	76
1664000	1.4572E-18	0.1579	0.2245	1.8 9.6E+00		1.5285E-20	0.0560	0.0345	3.3	76
1792000	1.9006E-18	0.2787	0.7054	1.9 2.8E+00		1.5603E-20	0.0555	0.0392	3.2	71
1920000	1.8313E-18	0.2702	0.7035	1.9 2.8E+00		1.5540E-20	0.0532	0.0364	3.1	72
2001291	1.8061E-18	0.2633	0.6987	1.9 2.8E+00		1.5418E-20	0.0522	0.0347	3.0	71

5.64 minutes
(cf. 6.21 minutes
F6: 394× FOM)

Listing 12: 2.5M Histories

	nps	tally			fom		tally			fom
		mean	error	vov			mean	error	vov	
128000	2.0024E-18	0.4245	0.3640	1.4	22	4.4545E-20	0.6012	0.9771	0.0	11
256000	1.3656E-18	0.3168	0.3393	1.8	18	3.1031E-20	0.4336	0.9586	2.2 9.6E+00	
384000	1.1840E-18	0.2627	0.2588	1.8	17	2.4107E-20	0.3726	0.9530	2.4 8.6E+00	
512000	1.0871E-18	0.2210	0.2312	1.8	18	2.0835E-20	0.3242	0.9436	2.5 8.4E+00	
640000	1.5634E-18	0.2502	0.2809	1.8	11	2.1389E-20	0.2600	0.8425	2.4	10
768000	1.4166E-18	0.2312	0.2756	1.7	10	2.2913E-20	0.2390	0.5108	2.2 9.8E+00	
896000	1.6462E-18	0.1888	0.1898	1.7	13	2.1715E-20	0.2171	0.5019	2.2 9.9E+00	
1024000	1.5060E-18	0.1809	0.1886	1.8	12	2.0776E-20	0.1990	0.4977	2.4	10
1152000	1.5566E-18	0.1728	0.1519	1.8	12	1.9528E-20	0.1884	0.4954	2.5	10
1280000	1.5400E-18	0.1631	0.1351	1.9	12	1.8975E-20	0.1748	0.4913	2.5	10
1408000	1.4878E-18	0.1551	0.1297	2.0	12	1.8559E-20	0.1629	0.4865	2.6	11
1536000	1.6692E-18	0.1746	0.2475	2.0 8.4E+00		1.8372E-20	0.1515	0.4783	2.7	11
1664000	1.6769E-18	0.1628	0.2337	2.0 8.8E+00		1.8271E-20	0.1409	0.4738	2.8	12
1792000	1.6311E-18	0.1567	0.2262	2.0 8.7E+00		1.7890E-20	0.1339	0.4706	2.8	12
1920000	1.7179E-18	0.1467	0.1858	2.0 9.2E+00		1.8125E-20	0.1246	0.4518	2.6	13
2001291	1.7369E-18	0.1423	0.1714	2.0 9.4E+00		1.8064E-20	0.1204	0.4459	2.6	13

5.76 minutes
(cf. 11.59 minutes
F6: 65× FOM)

CADIS Results: Detector (Proper Weight Normalization)

Listing 13: 2.5M Histories; wnrm = 1.178951288e-01

	nps	tally			fom	tally			fom
		mean	error	vov		mean	error	vov	
128000	2.0024E-18	0.4245	0.3640	1.4	22	4.4545E-20	0.6012	0.9771	0.0
256000	1.3656E-18	0.3168	0.3393	1.8	18	3.1031E-20	0.4336	0.9586	2.2 9.6E+00
384000	1.1840E-18	0.2627	0.2588	1.8	17	2.4107E-20	0.3726	0.9530	2.4 8.6E+00
512000	1.0871E-18	0.2210	0.2312	1.8	18	2.0835E-20	0.3242	0.9436	2.5 8.4E+00
640000	1.5634E-18	0.2502	0.2809	1.8	11	2.1389E-20	0.2600	0.8425	2.4 10
768000	1.4166E-18	0.2312	0.2756	1.7	10	2.2913E-20	0.2390	0.5108	2.2 9.8E+00
896000	1.6462E-18	0.1888	0.1898	1.7	13	2.1715E-20	0.2171	0.5019	2.2 9.9E+00
1024000	1.5060E-18	0.1809	0.1886	1.8	12	2.0776E-20	0.1990	0.4977	2.4 10
1152000	1.5566E-18	0.1728	0.1519	1.8	12	1.9528E-20	0.1884	0.4954	2.5 10
1280000	1.5400E-18	0.1631	0.1351	1.9	12	1.8975E-20	0.1748	0.4913	2.5 10
1408000	1.4878E-18	0.1551	0.1297	2.0	12	1.8559E-20	0.1629	0.4865	2.6 11
1536000	1.6692E-18	0.1746	0.2475	2.0 8.4E+00		1.8372E-20	0.1515	0.4783	2.7 11
1664000	1.6769E-18	0.1628	0.2337	2.0 8.8E+00		1.8271E-20	0.1409	0.4738	2.8 12
1792000	1.6311E-18	0.1567	0.2262	2.0 8.7E+00		1.7890E-20	0.1339	0.4706	2.8 12
1920000	1.7179E-18	0.1467	0.1858	2.0 9.2E+00		1.8125E-20	0.1246	0.4518	2.6 13
2001291	1.7369E-18	0.1423	0.1714	2.0 9.4E+00		1.8064E-20	0.1204	0.4459	2.6 13

5.76 minutes
(cf. 11.59 minutes
F6: 65× FOM)

Listing 14: 2.5M Histories; wnrm = 5.178951288e-01

	nps	tally			fom	tally			fom
		mean	error	vov		mean	error	vov	
128000	9.7039E-19	0.4364	0.3671	1.3	74	1.4069E-20	0.2782	0.1859	0.0 102
256000	6.1732E-19	0.3595	0.3112	1.4	51	1.3235E-20	0.1809	0.0962	0.0 201
384000	9.4504E-19	0.3438	0.4401	1.4	36	1.5082E-20	0.1548	0.0955	0.0 176
512000	1.0168E-18	0.2962	0.2947	1.4	35	1.7161E-20	0.1468	0.1178	0.0 142
640000	1.3346E-18	0.3359	0.4868	1.5	22	1.7318E-20	0.1313	0.0833	0.0 142
768000	1.1831E-18	0.3165	0.4823	1.6	20	1.5821E-20	0.1247	0.0750	0.0 130
896000	1.1519E-18	0.2829	0.4542	1.6	22	1.4856E-20	0.1163	0.0691	0.0 129
1024000	1.2306E-18	0.2651	0.3145	1.7	22	1.4360E-20	0.1076	0.0636	3.0 131
1152000	1.1343E-18	0.2566	0.3099	1.7	21	1.3797E-20	0.1032	0.0575	2.9 127
1280000	1.0522E-18	0.2495	0.3072	1.8	19	1.3689E-20	0.0970	0.0512	3.6 129
1408000	1.7385E-18	0.3688	0.6933	1.7 8.0E+00		1.4246E-20	0.0930	0.0424	3.9 127
1536000	1.6112E-18	0.3648	0.6929	1.7 7.6E+00		1.3772E-20	0.0895	0.0401	4.7 126
1664000	1.8091E-18	0.3165	0.5661	1.7 9.2E+00		1.5240E-20	0.1265	0.4023	2.5 58
1792000	1.7976E-18	0.2994	0.5398	1.7 9.5E+00		1.4784E-20	0.1220	0.3905	2.9 57
1920000	1.7152E-18	0.2930	0.5384	1.7 9.3E+00		1.4742E-20	0.1166	0.3607	2.9 59
2001291	1.7001E-18	0.2847	0.5306	1.7 9.4E+00		1.4739E-20	0.1127	0.3495	2.7 60

1.72 minutes
(cf. 11.59 minutes
F6: 250× FOM)

Summary & Future Work

Summary

- ▶ Weight is being correctly preserved regardless of number of histories
 - ▶ This is often not intuitive/obvious from output quantities
 - ▶ That said, diagnostics in the output can be used to track behavior
- ▶ Ensure consistency with kcode-bootstrapped source weights and VR
 - ▶ CADIS-centric tools likely don't (can't?) account for this
- ▶ Large ASCII weight-window files can take non-trivial time to read

Future Work

- ▶ Parallelize surface-source write operation
 - ▶ In otherwise parallel workflows; this is a major bottleneck
- ▶ Improve output quantity clarity (don't require reading input echo)
- ▶ Convert weight-window files to HDF5
 - ▶ Less storage, greater speed, easier post-processing/visualization

Questions?

Background and Motivation

A (Brief) Review of Statistical Weight

Primer Example 1: Spallation Neutron Source [1]

Overview of Model & Computational Process

Weight Versus Sampling (versus Proton Population)

Primer Example 2: Criticality Accident Alarm System [2]

Overview of Model & Computational Process

Sampling Coverage versus Results

FW-CADIS, and “Global” Dose Rate

Summary & Future Work

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Backup Slides

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References

Abstract

References

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Go Home ChatGPT—You're Hallucinating

What does the "A" mean in the file names "rssa" and "wssa" in the MCNP code?



In MCNP, the "A" means ASCII.

- **WSSA = Write Surface Source ASCII**
- **RSSA = Read Surface Source ASCII**

They are the ASCII/text versions associated with MCNP's surface-source write/read capability (SSW / SSR). The distinction matters because the traditional surface-source file is typically a binary/unformatted file, while the `...A` form is an ASCII representation useful for portability, inspection, or manipulation.

So the naming is essentially **RSS/WSS + A = ASCII**.



Spallation Neutron Source Inputs (Electronically Attached)

```

1 Proton source on Tungsten target
2 c Cell Cards
3 10 0 +1 -9 imp:h,n=1
4 20 0 -1 +2 -9 imp:h,n=1
5 30 100 -19.25 -2 imp:h,n=1
6 99 0 +9 imp:h,n=0
7
8 c Surface Cards
9 1 px 10
10 2 rpp 2.5 5 -2.5 2.5 -2.5 2.5
11 9 rpp -15 15 -15 15 -15 15
12
13 c Data Cards
14 mode h n
15 c
16 phys:h 150
17 sdef par=h erg=150 vec=1 0 0 dir=1
18 c
19 m100 74184 1.0
20 c
21 fmesh4:h geom=xyz origin=-5 -5 -5
22 imesh= 5 iints=150
23 jmesh= 5 jints=150
24 kmesh= 5 kints=150
25 out=none
26 c
27 fmesh14:n geom=xyz origin=-15 -15 -15
28 imesh=15 iints=150
29 jmesh=15 jints=150
30 kmesh=15 kints=150
31 out=none
32 c
33 nps 1E5
34 rand gen=2 seed=12345
35 ssw 1 pty=n
    
```

```

1 Neutron spallation source read
2 c Cell Cards
3 10 0 -11 -9 imp:n=1
4 20 0 +11 -2 -9 imp:n=1
5 30 100 -1.0 +2 +4 -5 -9 imp:n=1
6 40 200 -7.874 +2 +3 -4 -5 imp:n=1
7 50 0 +2 -3 -5 imp:n=1
8 60 0 +5 -9 imp:n=1
9 99 0 +9 imp:n=0
10
11 c Surface Cards
12 11 px 5
13 2 px 10
14 3 cx 2.5
15 4 cx 7.5
16 5 px 60
17 9 rpp 0 100 -25 25 -25 25
18
19 c Data Cards
20 mode n
21 c
22 c Materials
23 c
24 m100 1001 2 8016 1 5010 2
25 mt100 lwtr
26 m200 26056 1.0
27 c
28 f4:n 60
29 e4 1e-6 99ilog 30
30 c
31 fmesh14:n geom=xyz origin= 0 -25 -25
32 imesh=100 iints=200
33 jmesh=25 jints=50
34 kmesh=25 kints=50
35 out=none
36 c
37 tr1 -5 0 0
38 ssr new 11 tr=1
39 print
40 rand gen=2 seed=12345
41 nps 23829
    
```

CAAS MCNP Input (Electronically Attached)

```

CAAS Primer
c >>>> accident tank
100 1 9.9270e-2 -10 -12      imp:n=1
101 3 4.8333e-5 -10 -12      imp:n=1
102 2 8.6300e-2 +10 -11      imp:n=1
c
c >>>> facility rooms: nw. -> ne., sw. -> se.
c
200 3 4.8333e-5 -20 +11      imp:n=1
201 3 4.8333e-5 -21 +11      imp:n=1
202 3 4.8333e-5 -22          imp:n=1
203 3 4.8333e-5 -23          imp:n=1
204 3 4.8333e-5 -24          imp:n=1
205 3 4.8333e-5 -25 +40      imp:n=1
c >>>> doorways
c
206 3 4.8333e-5 -30          imp:n=1
207 3 4.8333e-5 -31          imp:n=1
208 3 4.8333e-5 -32          imp:n=1
209 3 4.8333e-5 -33          imp:n=1
210 3 4.8333e-5 -34          imp:n=1
211 3 4.8333e-5 -35          imp:n=1
212 3 4.8333e-5 -36          imp:n=1
c
c >>>> detector
c
300 5 -9.2e-1 -41            imp:n=1
c
c >>>> facility and rest of world
c
900 4 0.0764 -.99 +20 +21 +22 +23 +24 +25
    +35 +36                  imp:n=1
901 4 0.0764 -.40            imp:n=1
999 0 +99                    imp:n=0
c
c >>>> critical experiment tank
10 rcc 0 0 1 0 0 100 50
11 rcc 0 0 0 0 0 101 50.5
12 nx 13.6
c
c >>>> rpp's for the empty space in the rooms
20 rpp -1250 -250 -800 200 0 300 $ northwest room
21 rpp -200 800 -800 200 0 300 $ north (accident) room
22 rpp 850 1850 -800 200 0 300 $ northeast room
23 rpp -1250 -250 -1850 850 0 300 $ southwest room
24 rpp -200 800 -1850 850 0 300 $ south room
25 rpp 850 1850 -1850 850 0 300 $ southeast room
c
c >>>> doorways
30 rpp -250 -200 -800 -700 0 250 $ nw. to n. door
31 rpp 800 850 100 200 0 250 $ n. to ne. door
32 rpp -1250 -1150 -850 -800 0 250 $ nw. to sw. door
33 rpp 700 800 -850 -800 0 250 $ n. to s. door
34 rpp -250 -200 -1850 -1750 0 250 $ sw. to s. door

35 rpp 800 850 -1850 -1750 0 250 $ s. to se. door
36 rpp 1750 1850 -1900 -1850 0 250 $ sw. exit
c
c >>>> other objects in rooms
40 rpp 950 1000 -1850 -.950 0 300 $ labyrinth wall
41 sph -255 -300 295 5.0
c
c >>>> building structure
99 rpp -1300 1900 -1900 250 -50 310
c
c plutonium nitrate solution
m1 1001 6.0070e-2
    8010 3.6540e-2
    7014 2.3699e-3
    94230 2.7682e-4
    94240 1.2214e-5
    94241 8.3390e-7
    94242 4.5800e-8
c
m1 lwtr
c stainless steel
m2 24050 7.1866e-4
    24052 1.3859e-2
    24053 1.5715e-3
    24054 3.9117e-4
    26054 3.7005e-3
    26056 5.8090e-2
    26057 1.3415e-3
    26058 1.7853e-4
    28058 4.4318e-3
    28060 1.7071e-3
    28061 7.4207e-5
    28062 2.3661e-4
    28064 6.8256e-5
c dry air (typical of American Southwest)
m3 1001 1.7404e-10
    1002 1.3065e-14
    2003 8.3540e-16
    2004 4.5540e-10
    6000 1.11008e-08
    7014 3.8901e-05
    7015 1.3515e-07
    8010 9.1205e-06
    8017 3.4348e-09
    18036 3.0439e-10
    18038 5.3915e-11
    18040 8.0974e-08
    36070 1.7811e-14
    36080 1.1164e-13
    36082 5.6154e-13
    36083 5.4995e-13
    36084 2.69359e-12
    36086 7.98400e-13
    54124 2.38540e-13
c
m3 lwtr
c los alamos concrete
m4 1001 0.00842
    8016 0.04423

13027 0.00252
14028 0.014600958
14029 0.000718176
14030 0.000460866
11023 0.00105
20040 2.64037e-03
20042 1.89571e-05
20043 3.95550e-06
20044 6.11190e-05
20046 1.17200e-07
20048 5.47910e-06
26054 0.00004788
26056 0.000612083
26057 0.000014347
26058 0.000001862
19039 8.43481e-04
19040 8.07300e-08
19041 4.64384e-05
c
m4 lwtr
c
m5 1001 2
    6000 1
c
m5 poly
c
r5:n -255 -300 295 1
fm5 1.6022e-10 $ convert from MeV/g to Gy (J/kg)
c
f6:n 300
fm6 1.6022e-10 $ convert from MeV/g to Gy (J/kg)
c
f6esh4:n geom = xyz
    origin = -1250 -1850 0
    imesh = -250 -200 800 850 1850
    jints = 100 10 100 10 100
    kmesh = -850 -800 200
    jints = 100 10 100
    kmesh = 50 300
    kints = 5 25
    factor = 1.6022e-10
    out = none
c
sdef pos = 0 0 1
    rad = d1
    vec = 1 0 0
    axi = 0 0 1
    ext = d2
    erg = d3
c
s11 0 50
s12 -21 1
s12 0 12.6
s12 0 12.6
s12 -21 0
s12 -3 8.885247 3.802890 $ Pu-239 Watt: LA-UR-24-24602, Rev. 1, Listing 5.29
c
print
primp 2j 1
kcode 50000 1.0 50 150
rand gen2 seed=12345

```

CAAS ADVANTG Input (Electronically Attached)

```
1 from advantg.driver import run
2
3 inp = {
4     "method":          "fwcadis",
5     "mcnp_input":      "caas2_advantg.mcnp.inp",
6     "mcnp_tallies":    [ 5 ],
7     "silo_wv":         True,
8     "anisn_library":   "27n19g",
9     "denovo_x_blocks": 5,
10    "denovo_y_blocks": 5,
11    "denovo_z_blocks": 4,
12    "denovo_pn_order": 1,
13    "denovo_quad_num_polar": 4,
14    "denovo_quad_num_azimuth": 4,
15    "mcnp_min_rays_per_face": 100,
16    "mesh_x":          [ -1300, 1900 ],
17    "mesh_x_ints":      [      320 ],
18    "mesh_y":          [ -1900, 250 ],
19    "mesh_y_ints":      [      215 ],
20    "mesh_z":          [   -50, 310 ],
21    "mesh_z_ints":      [      36 ]
22 }
23
24 run(inp)
```

Abstract

The purpose of this talk is to describe the evolution of statistical weight through MCNP surface-source write (SSW) and surface-source read (SSR) calculations. How weight is related through these calculations, particularly when fewer or more histories are sampled than are on the surface-source file, has been observed as a source of perennial confusion, so this talk attempts to resolve that confusion using examples from MCNP primers (and classes). This approach is taken to rely on (hopefully) familiar examples that resemble a couple typical analysis workflows, which are thus expected to be of interest to the MCNP Symposium community at large.