Report of Experiment Cache Efficient Matrix Transpose

Name: Zekihan AZMAN
Number: 250201007

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General Findings

In some parts you may need to go to appendix section. All data are in appendix B as well as modified code in appendix A.

I tested with a variety of cache configurations.
combination of 8KB 16KB 32KB 64KB for cache size,
combination of 8B 16B 32B 64B for block size,
combination of 4 16 32 for associativity,
combination of 256 512 1024 2048 for array size,
and additionally 1 2 4 8 16 32 64 associativity with 64B block and 64KB cache size, 256 array size.

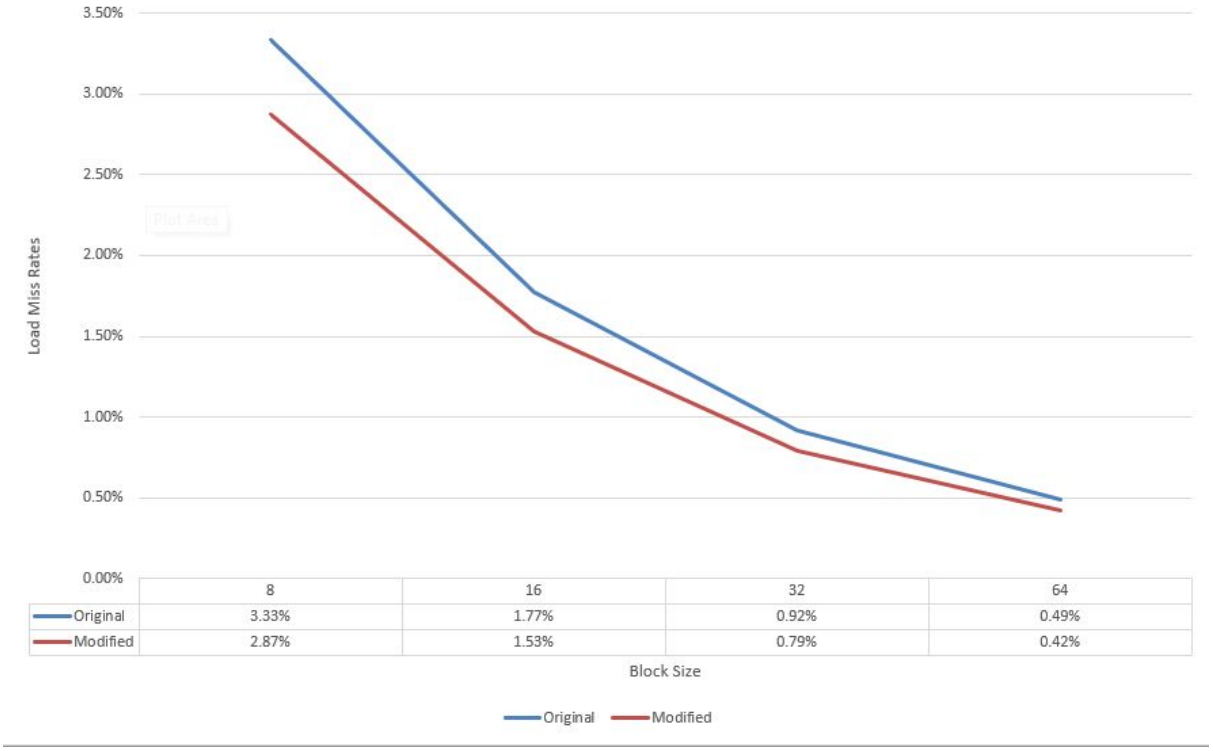
For any cache config there appears to be no significant execution time benefit for any array size for both original or modified code. Though there are some changes to execution times they are mostly pretty random as cannot be included as findings.

Generally there is a very high store miss rates due to storing into empty cache which results in compulsory miss. This can be decreased if used same matrix as destination with some other tricks but as load miss rates our main focus in this experiment i did not use it.

Parameter: Modified Code

As seen in appendix A modified code, I used blocking method to decrease miss rates. But as i tweaked with “blocksize” parameter i realized that there is no miss rate change is happening. But decreasing it makes execution time faster until some point. So that I settled at 4.

Parameter: Block Size



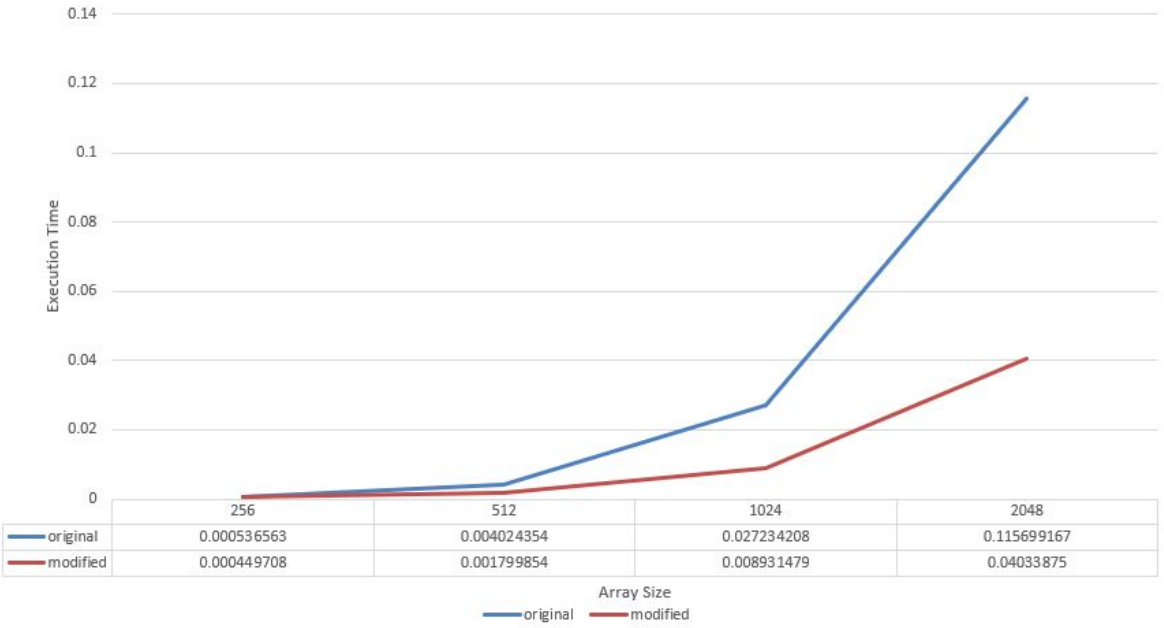
Block Size(B) X Load Miss Rate

As block size increases load miss rates drop almost gets halved for every doubling of block size. An increase in block size to a certain extent can exploit spatial locality. As matrix transpose largely benefit from spatial locality any increase in block size leads to a decrease in miss rates.

In smaller array sizes block sizes benefit is more clear. Since less new block is needed.

Parameter: Array Size

Normal execution

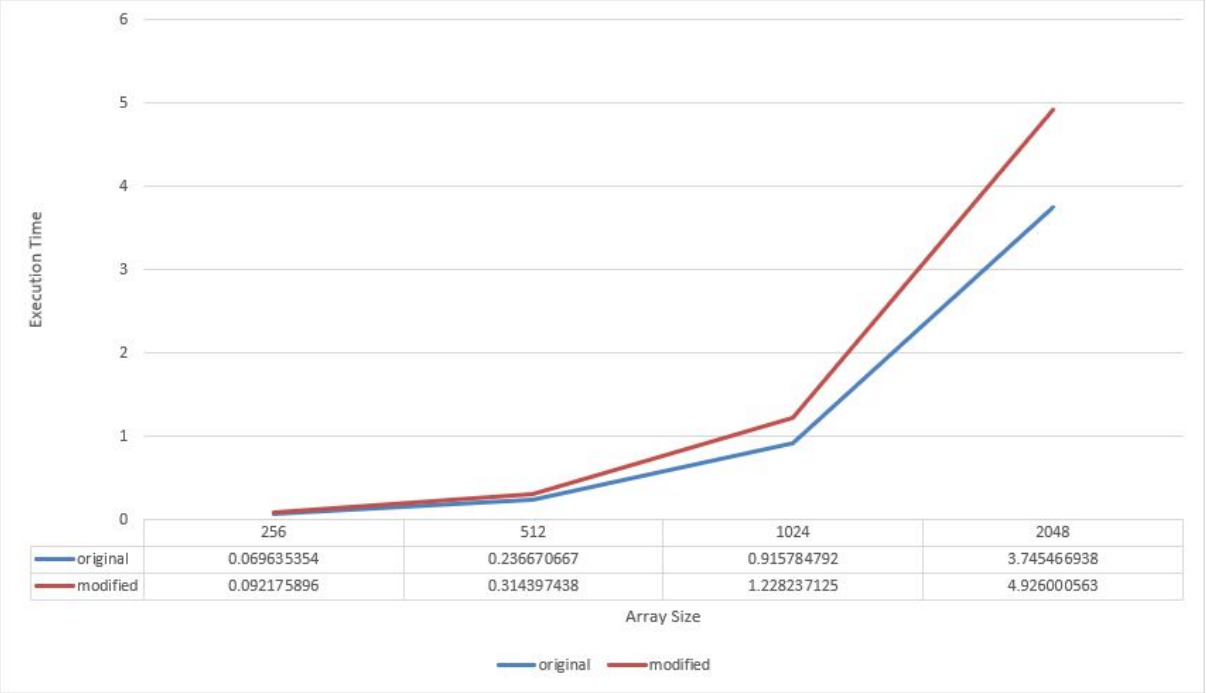


	256	512	1024	2048
original	0.000536563	0.004024354	0.027234208	0.115699167
modified	0.000449708	0.001799854	0.008931479	0.04033875

Array Size X Execution Time(s)
(This values is obtained by simply running code and when not using pin tools).

As expected for both modified and original code as array size gets bigger execution time gets bigger. When array size is relatively small their execution times almost is the same but as we get bigger array size, execution time difference between them start to get bigger and bigger. In array size 2048, execution time of modified code is almost 3 times better than original code.

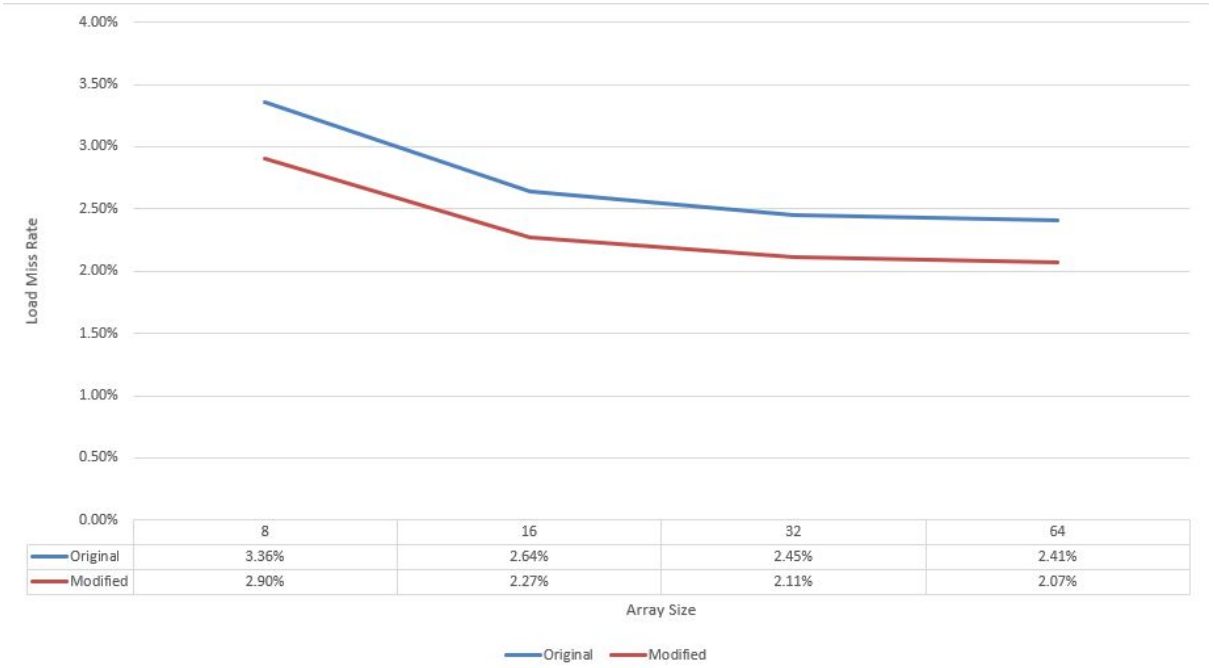
Execution With Pin Tools



Array Size X Execution Time(s)
(This values is obtained by averaging all values for different cache configuration when using pin tools).

Unexpectedly as array size gets bigger execution time of modified code behaved worse than original code. Main issue of modified code, it has more instruction than original. As pin tools interject with every instruction to calculate cache miss rates it makes it slower than original code.

Load Miss Rate

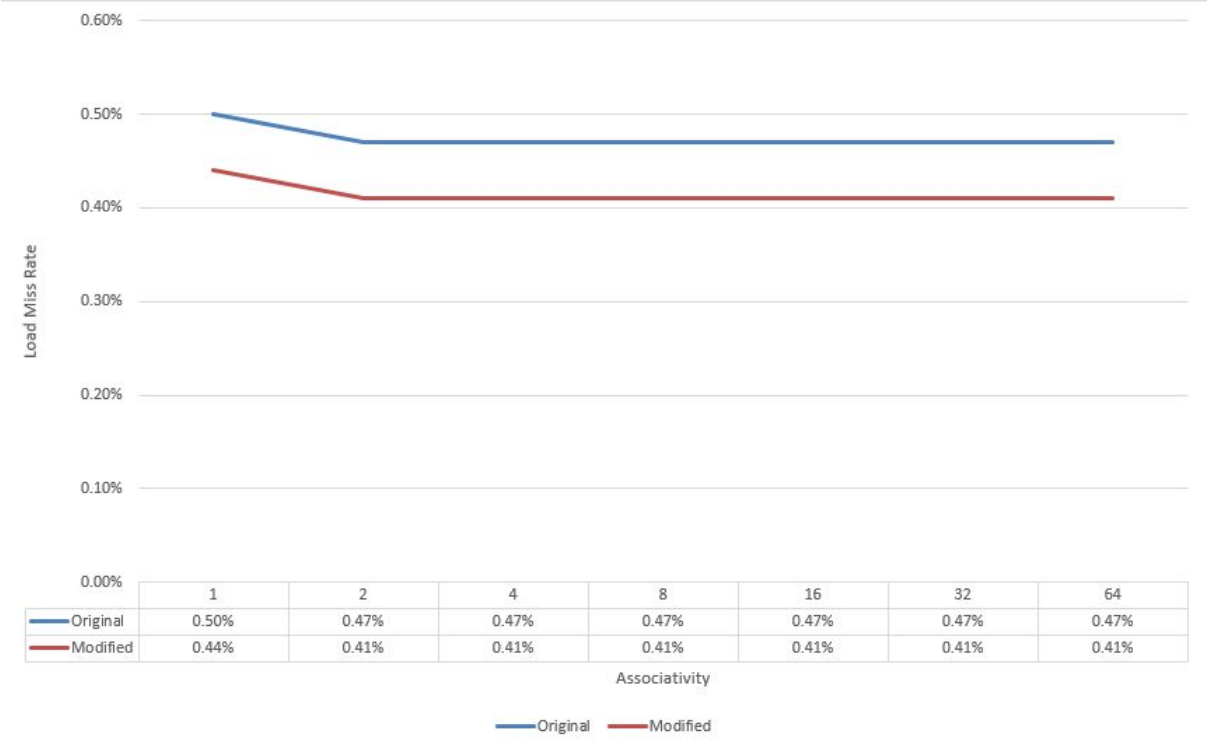


	8	16	32	64
Original	3.36%	2.64%	2.45%	2.41%
Modified	2.90%	2.27%	2.11%	2.07%

Array Size X Load Miss Rate

As array size got bigger miss rate is decreased. This happened due to huge amount of access. As access amount is increased miss rate does not increase proportionally.

Parameter: Associativity



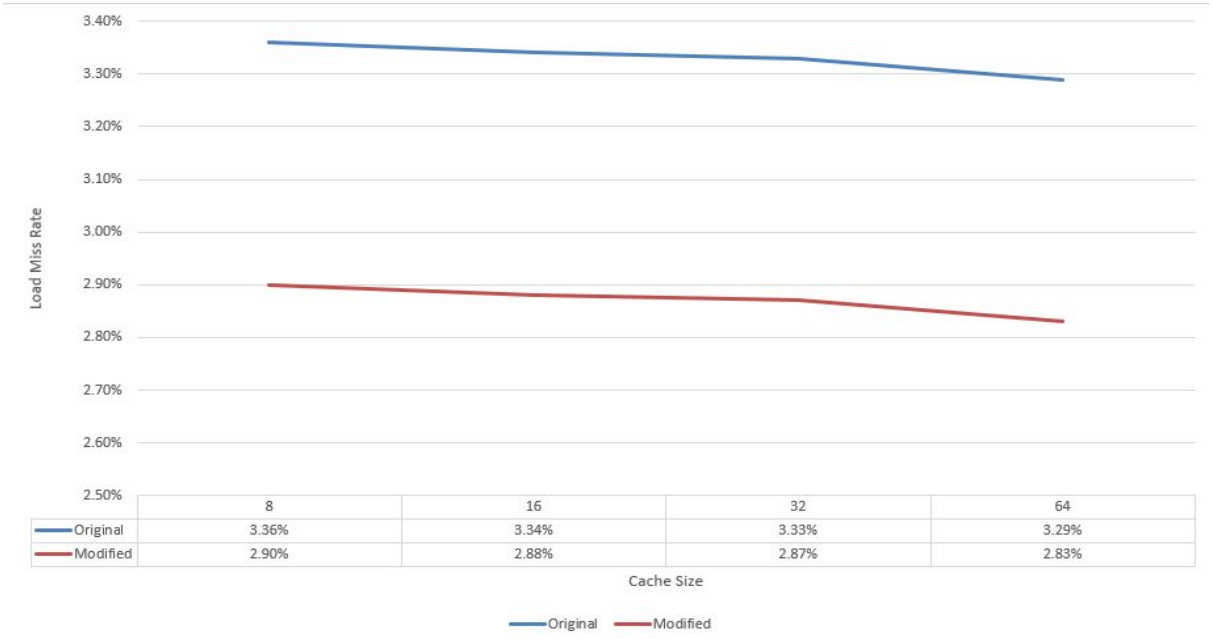
	1	2	4	8	16	32	64
Original	0.50%	0.47%	0.47%	0.47%	0.47%	0.47%	0.47%
Modified	0.44%	0.41%	0.41%	0.41%	0.41%	0.41%	0.41%

Associativity X Load Miss Rate

Unexpectedly associativity has no effect on load miss rates or store miss rate execution times or any other parameter for both original and modified code unless associativity is 1 in that case as its direct-mapped it resulted in a little bit higher miss rates. As there is no conflict misses associativity offers no amount of decrease in miss rates.

Parameter: Cache Size

Array Size = 256

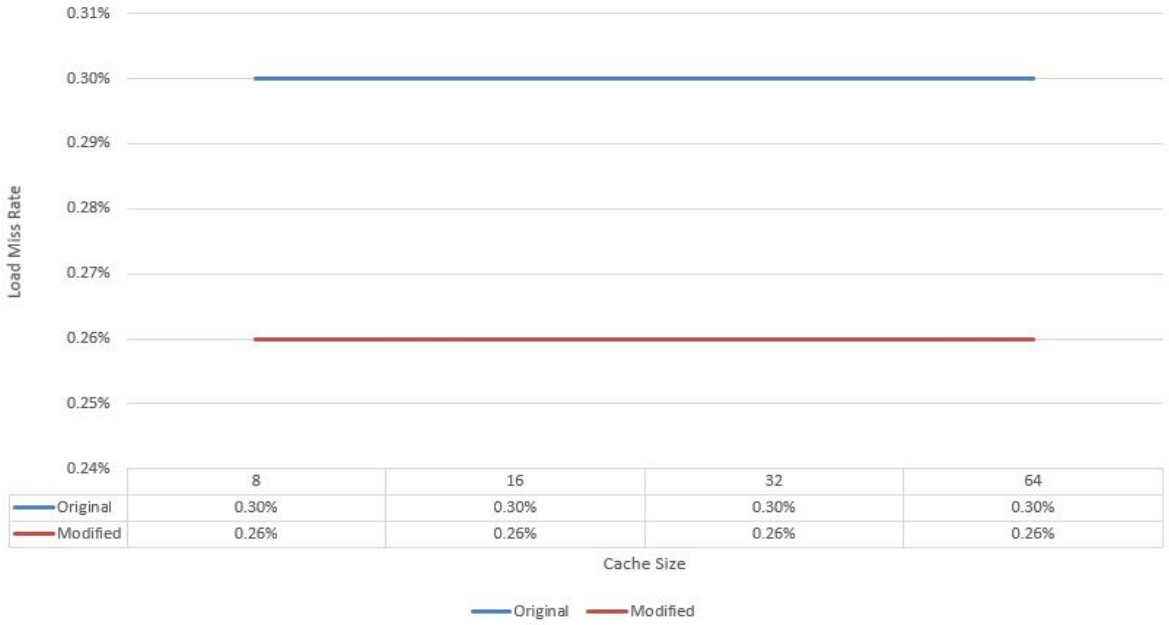


	8	16	32	64
Original	3.36%	3.34%	3.33%	3.29%
Modified	2.90%	2.88%	2.87%	2.83%

Cache Size(KB) X Load Miss Rate

Cache size have some minor effect when array size small enough that cache size can contain more than few row.

Array Size = 2048



	8	16	32	64
Original	0.30%	0.30%	0.30%	0.30%
Modified	0.26%	0.26%	0.26%	0.26%

Cache Size(KB) X Load Miss Rate

In array size 2048 unexpectedly cache size has no effect on load miss rates or store miss rate for both original and modified code. As cache size much smaller than array size cache is always full which leads to no difference in miss rates as cache size increases.

Appendix A: Modified Code

```
int blocksize = 4;
for (int ii = 0; ii < dimension; ii += blocksize)
{
    for (int jj = 0; jj < dimension; jj += blocksize)
    {
        for (int i = ii; i < ii + blocksize; ++i)
        {
            for (int j = jj; j < jj + blocksize; ++j)
            {
                dst[i + j*dimension] = src[j + i*dimension];
            }
        }
    }
}
```

Appendix B: Data

index	cache size	block size	assoc	array size	elapsed	mod-elapsed	elapsed-pin	mod-elapsed-pin	load	mod-load	store	mod-store	total	mod-total	time diff	load diff	store diff	total diff
1	8	8	4	256	0.000486	0.000432	0.068207	0.088905	3.36%	2.90%	39.73%	35.52%	10.40%	9.03%	-0.000054	0.46%	4.21%	1.37%
2	8	8	4	512	0.004053	0.001738	0.227646	0.305160	2.64%	2.27%	39.90%	35.53%	9.82%	8.49%	-0.002315	0.37%	4.37%	1.33%
3	8	8	4	1024	0.028492	0.008590	0.881836	1.190880	2.45%	2.11%	39.96%	35.54%	9.67%	8.35%	-0.019902	0.34%	4.42%	1.32%
4	8	8	4	2048	0.115867	0.038238	3.620294	4.774065	2.41%	2.07%	39.98%	35.55%	9.63%	8.32%	-0.077629	0.34%	4.43%	1.31%
5	8	8	16	256	0.000640	0.000431	0.070073	0.091435	3.36%	2.90%	39.72%	35.50%	10.40%	9.03%	-0.000209	0.46%	4.22%	1.37%
6	8	8	16	512	0.004578	0.001739	0.232655	0.311799	2.64%	2.27%	39.90%	35.53%	9.82%	8.49%	-0.002839	0.37%	4.37%	1.33%
7	8	8	16	1024	0.030799	0.009424	0.950064	1.225033	2.45%	2.11%	39.96%	35.54%	9.67%	8.35%	-0.021375	0.34%	4.42%	1.32%
8	8	8	16	2048	0.115243	0.040990	3.772976	4.871197	2.41%	2.07%	39.98%	35.55%	9.63%	8.32%	-0.074253	0.34%	4.43%	1.31%
9	8	8	32	256	0.000486	0.000422	0.073299	0.096714	3.36%	2.90%	39.72%	35.50%	10.40%	9.03%	-0.000064	0.46%	4.22%	1.37%
10	8	8	32	512	0.004275	0.001868	0.251065	0.335693	2.64%	2.27%	39.90%	35.53%	9.82%	8.49%	-0.002407	0.37%	4.37%	1.33%
11	8	8	32	1024	0.029177	0.008315	1.011035	1.306799	2.45%	2.11%	39.96%	35.54%	9.67%	8.35%	-0.020862	0.34%	4.42%	1.32%
12	8	8	32	2048	0.109601	0.038951	4.140215	5.242752	2.41%	2.07%	39.98%	35.55%	9.63%	8.32%	-0.070650	0.34%	4.43%	1.31%
13	8	16	4	256	0.000489	0.000440	0.066378	0.088473	1.81%	1.56%	39.56%	35.35%	9.12%	7.91%	-0.000049	0.25%	4.21%	1.21%
14	8	16	4	512	0.003902	0.001894	0.227902	0.304959	1.35%	1.16%	39.87%	35.49%	8.77%	7.58%	-0.002008	0.19%	4.38%	1.19%
15	8	16	4	1024	0.026873	0.008701	0.875455	1.205938	1.24%	1.06%	39.95%	35.53%	8.69%	7.50%	-0.018172	0.18%	4.42%	1.19%
16	8	16	4	2048	0.117827	0.040514	3.586563	4.715242	1.21%	1.04%	39.98%	35.55%	8.66%	7.48%	-0.077313	0.17%	4.43%	1.18%
17	8	16	16	256	0.000533	0.000463	0.070052	0.092520	1.80%	1.56%	39.58%	35.35%	9.12%	7.91%	-0.000070	0.24%	4.23%	1.21%
18	8	16	16	512	0.004076	0.001792	0.232124	0.309260	1.35%	1.16%	39.86%	35.49%	8.77%	7.59%	-0.002284	0.19%	4.37%	1.18%
19	8	16	16	1024	0.024525	0.009112	0.896864	1.213738	1.24%	1.06%	39.95%	35.53%	8.69%	7.50%	-0.015413	0.18%	4.42%	1.19%
20	8	16	16	2048	0.120035	0.037800	3.705195	4.840619	1.21%	1.04%	39.98%	35.55%	8.66%	7.48%	-0.082235	0.17%	4.43%	1.18%
21	8	16	32	256	0.000526	0.000475	0.072481	0.096334	1.80%	1.56%	39.57%	35.35%	9.12%	7.91%	-0.000051	0.24%	4.22%	1.21%
22	8	16	32	512	0.004071	0.001763	0.247584	0.332441	1.35%	1.16%	39.86%	35.49%	8.77%	7.58%	-0.002308	0.19%	4.37%	1.19%
23	8	16	32	1024	0.024269	0.007910	0.960464	1.291349	1.24%	1.06%	39.95%	35.53%	8.69%	7.50%	-0.016359	0.18%	4.42%	1.19%
24	8	16	32	2048	0.116023	0.040826	3.885060	5.204876	1.21%	1.04%	39.98%	35.55%	8.66%	7.48%	-0.075197	0.17%	4.43%	1.18%
25	8	32	4	256	0.000573	0.000469	0.067196	0.089825	0.95%	0.83%	39.42%	35.25%	8.40%	7.30%	-0.000104	0.12%	4.17%	1.10%
26	8	32	4	512	0.004857	0.001716	0.229845	0.301949	0.69%	0.61%	39.83%	35.46%	8.23%	7.13%	-0.003141	0.08%	4.37%	1.10%
27	8	32	4	1024	0.024265	0.007961	0.866605	1.173919	0.62%	0.57%	39.94%	35.52%	8.19%	7.10%	-0.016304	0.05%	4.42%	1.09%
28	8	32	4	2048	0.109831	0.041430	3.684718	4.712328	0.61%	0.54%	39.98%	35.54%	8.18%	7.08%	-0.068401	0.07%	4.44%	1.10%
29	8	32	16	256	0.000491	0.000438	0.069384	0.091126	0.95%	0.82%	39.43%	35.24%	8.40%	7.29%	-0.000053	0.13%	4.19%	1.11%
30	8	32	16	512	0.004259	0.001945	0.239791	0.308658	0.69%	0.59%	39.82%	35.46%	8.23%	7.11%	-0.002314	0.10%	4.36%	1.12%
31	8	32	16	1024	0.025319	0.009276	0.889184	1.203991	0.62%	0.54%	39.94%	35.52%	8.19%	7.07%	-0.016043	0.08%	4.42%	1.12%
32	8	32	16	2048	0.119674	0.043153	3.659592	4.878405	0.61%	0.52%	39.98%	35.54%	8.18%	7.06%	-0.076521	0.09%	4.44%	1.12%
33	8	32	32	256	0.000643	0.000477	0.071676	0.098847	0.95%	0.82%	39.43%	35.23%	8.40%	7.29%	-0.000166	0.13%	4.20%	1.11%
34	8	32	32	512	0.003819	0.001841	0.248871	0.331815	0.69%	0.59%	39.82%	35.46%	8.23%	7.12%	-0.001978	0.10%	4.36%	1.11%
35	8	32	32	1024	0.027280	0.009318	0.951733	1.295777	0.62%	0.54%	39.94%	35.52%	8.19%	7.07%	-0.017962	0.08%	4.42%	1.12%
36	8	32	32	2048	0.107625	0.040542	3.918675	5.121364	0.61%	0.52%	39.98%	35.54%	8.18%	7.06%	-0.067083	0.09%	4.44%	1.12%
37	8	64	4	256	0.000468	0.000426	0.067586	0.088933	0.53%	0.46%	39.37%	35.20%	8.05%	6.99%	-0.000042	0.07%	4.17%	1.06%
38	8	64	4	512	0.003880	0.001801	0.228744	0.300647	0.36%	0.37%	39.81%	35.46%	7.96%	6.93%	-0.002079	-0.01%	4.35%	1.03%
39	8	64	4	1024	0.024332	0.008265	0.880836	1.179808	0.32%	0.33%	39.94%	35.52%	7.94%	6.91%	-0.016067	-0.01%	4.42%	1.03%
40	8	64	4	2048	0.123397	0.038608	3.534695	4.712658	0.31%	0.29%	39.98%	35.54%	7.94%	6.87%	-0.084789	0.02%	4.44%	1.07%
41	8	64	16	256	0.000475	0.000429	0.068181	0.092033	0.53%	0.46%	39.36%	35.18%	8.05%	6.98%	-0.000046	0.07%	4.18%	1.07%
42	8	64	16	512	0.004492	0.001766	0.231141	0.312080	0.36%	0.31%	39.81%	35.44%	7.96%	6.88%	-0.002726	0.05%	4.37%	1.08%
43	8	64	16	1024	0.034173	0.009059	0.891683	1.195955	0.32%	0.27%	39.94%	35.52%	7.94%	6.86%	-0.025114	0.05%	4.42%	1.08%
44	8	64	16	2048	0.122252	0.037439	3.763999	4.792580	0.31%	0.26%	39.98%	35.54%	7.94%	6.85%	-0.084813	0.05%	4.44%	1.09%
45	8	64	32	256	0.000492	0.000470	0.071741	0.095778	0.53%	0.46%	39.37%	35.19%	8.05%	6.99%	-0.000022	0.07%	4.18%	1.06%
46	8	64	32	512	0.003940	0.001726	0.246323	0.328237	0.36%	0.31%	39.81%	35.44%	7.96%	6.88%	-0.002214	0.05%	4.37%	1.08%
47	8	64	32	1024	0.029485	0.008697	0.934998	1.275585	0.32%	0.27%	39.94%	35.52%	7.94%	6.86%	-0.020788	0.05%	4.42%	1.08%
48	8	64	32	2048	0.123487	0.039846	3.952750	5.104569	0.30%	0.26%	39.98%	35.54%	7.93%	6.85%	-0.083641	0.04%	4.44%	1.08%
49	16	8	4	256	0.000522	0.000470	0.070563	0.088936	3.34%	2.88%	39.70%	35.49%	10.38%	9.01%	-0.000052	0.46%	4.21%	1.37%
50	16	8	4	512	0.003831	0.001802	0.224166	0.304399	2.63%	2.26%	39.89%	35.52%	9.81%	8.48%	-0.002029	0.37%	4.37%	1.33%
51	16	8	4	1024	0.024152	0.008841	0.880269	1.186065	2.45%	2.10%	39.96%	35.54%	9.66%	8.35%	-0.015311	0.35%	4.42%	1.31%
52	16	8	4	2048	0.109489	0.039463	3.587335	4.774262	2.40%	2.06%	39.98%	35.55%	9.63%	8.31%	-0.070026	0.34%	4.43%	1.32%
53	16	8	16	256	0.000530	0.000472	0.068752	0.091902	3.34%	2.88%	39.70%	35.48%	10.38%	9.01%	-0.000058	0.46%	4.22%	1.37%
54	16	8	16	512	0.003970	0.001785	0.238247	0.313032	2.63%	2.26%	39.89%	35.52%	9.81%	8.48%	-0.002185	0.37%	4.37%	1.33%
55	16	8	16	1024	0.027569	0.007833	0.923636	1.212952	2.45%	2.10%	39.96%	35.54%	9.66%	8.35%	-0.019736	0.35%	4.42%	1.31%
56	16	8	16	2048	0.110417	0.038195	3.722920	4.851905	2.40%	2.06%	39.98%	35.55%	9.63%	8.31%	-0.072222	0.34%	4.43%	1.32%
57	16	8	32	256	0.000559	0.000428	0.073768	0.094380	3.34%	2.88%	39.70%	35.48%	10.38%	9.01%	-0.000131	0.46%	4.22%	1.37%
58	16	8	32	512	0.004252	0.001750	0.255050	0.332558	2.63%	2.26%	39.89%	35.52%	9.81%	8.48%	-0.002502	0.37%	4.37%	1.33%
59	16	8	32	1024	0.026064	0.008242	0.962010	1.304620	2.45%	2.10%	39.96%	35.54%	9.66%	8.35%	-0.017822	0.35%	4.42%	1.31%
60	16	8	32	2048	0.108675	0.041554	3.927829	5.229680	2.40%	2.06%	39.98%	35.55%	9.63%	8.31%	-0.067121	0.34%	4.43%	1.32%
61	16	16	4	256	0.000496	0.000430	0.066876	0.089166	1.79%	1.54%	39.52%	35.33%	9.09%	7.89%	-0.000066	0.25%	4.19%	1.20%
62	16	16	4	512	0.003822	0.002005	0.226705	0.304542	1.35%	1.16%	39.85%	35.48%	8.77%	7.58%	-0.001817	0.19%	4.37%	1.19%
63	16	16	4	1024	0.028123	0.009612	0.906069	1.205115	1.23%	1.06%	39.95%	35.53%	8.68%	7.50%	-0.018511	0.17%	4.42%	1.18%
64	16	16	4	2048	0.120063	0.040604	3.727976	4.730861	1.20%	1.03%	39.98%	35.55%	8.66%	7.48%	-0.079459	0.17%	4.43%	1.18%

65	16	16	16	256	0.000591	0.000431	0.069488	0.091357	1.79%	1.54%	39.52%	35.33%	9.09%	7.89%	-0.000160	0.25%	4.19%	1.20%
66	16	16	16	512	0.003682	0.001728	0.233566	0.310005	1.34%	1.16%	39.85%	35.48%	8.76%	7.58%	-0.001954	0.18%	4.37%	1.18%
67	16	16	16	1024	0.025647	0.009638	0.934799	1.210359	1.23%	1.06%	39.95%	35.53%	8.68%	7.50%	-0.016009	0.17%	4.42%	1.18%
68	16	16	16	2048	0.117724	0.041702	3.676044	4.848155	1.20%	1.03%	39.98%	35.55%	8.66%	7.48%	-0.076022	0.17%	4.43%	1.18%
69	16	16	32	256	0.000474	0.000419	0.071883	0.094271	1.79%	1.54%	39.52%	35.33%	9.09%	7.89%	-0.000055	0.25%	4.19%	1.20%
70	16	16	32	512	0.003970	0.001743	0.250786	0.331089	1.35%	1.16%	39.85%	35.48%	8.76%	7.58%	-0.002227	0.19%	4.37%	1.18%
71	16	16	32	1024	0.033052	0.009673	1.010316	1.304702	1.23%	1.06%	39.95%	35.53%	8.68%	7.50%	-0.023379	0.17%	4.42%	1.18%
72	16	16	32	2048	0.124400	0.038194	4.170753	5.182044	1.20%	1.03%	39.98%	35.55%	8.66%	7.48%	-0.086206	0.17%	4.43%	1.18%
73	16	32	4	256	0.000604	0.000479	0.066757	0.089347	0.93%	0.81%	39.40%	35.23%	8.38%	7.28%	-0.000125	0.12%	4.17%	1.10%
74	16	32	4	512	0.003889	0.001713	0.235194	0.301712	0.68%	0.59%	39.82%	35.45%	8.22%	7.11%	-0.002176	0.09%	4.37%	1.11%
75	16	32	4	1024	0.027794	0.008308	0.874857	1.176336	0.62%	0.54%	39.94%	35.52%	8.19%	7.08%	-0.019486	0.08%	4.42%	1.11%
76	16	32	4	2048	0.112444	0.039989	3.587255	4.678100	0.60%	0.53%	39.98%	35.54%	8.18%	7.07%	-0.072455	0.07%	4.44%	1.11%
77	16	32	16	256	0.000528	0.000593	0.067909	0.090854	0.93%	0.80%	39.40%	35.21%	8.38%	7.27%	0.000065	0.13%	4.19%	1.11%
78	16	32	16	512	0.003753	0.001760	0.233306	0.309736	0.68%	0.59%	39.81%	35.45%	8.22%	7.11%	-0.001993	0.09%	4.36%	1.11%
79	16	32	16	1024	0.026250	0.009658	0.896731	1.204182	0.62%	0.53%	39.94%	35.52%	8.19%	7.07%	-0.016592	0.09%	4.42%	1.12%
80	16	32	16	2048	0.123901	0.038398	3.655957	4.814246	0.60%	0.52%	39.98%	35.54%	8.18%	7.06%	-0.085503	0.08%	4.44%	1.12%
81	16	32	32	256	0.000468	0.000470	0.071238	0.096847	0.93%	0.80%	39.39%	35.21%	8.38%	7.27%	0.000002	0.13%	4.18%	1.11%
82	16	32	32	512	0.004429	0.001784	0.246003	0.328639	0.68%	0.59%	39.81%	35.45%	8.22%	7.11%	-0.002645	0.09%	4.36%	1.11%
83	16	32	32	1024	0.028430	0.008322	0.943810	1.290053	0.62%	0.53%	39.94%	35.52%	8.18%	7.07%	-0.020108	0.09%	4.42%	1.11%
84	16	32	32	2048	0.114202	0.038653	3.851387	5.121005	0.60%	0.52%	39.98%	35.54%	8.18%	7.06%	-0.075549	0.08%	4.44%	1.12%
85	16	64	4	256	0.000483	0.000467	0.067597	0.089261	0.50%	0.43%	39.32%	35.14%	8.02%	6.96%	-0.000016	0.07%	4.18%	1.06%
86	16	64	4	512	0.003882	0.001831	0.227601	0.305874	0.35%	0.30%	39.80%	35.43%	7.95%	6.87%	-0.002051	0.05%	4.37%	1.08%
87	16	64	4	1024	0.027353	0.008704	0.878274	1.179805	0.31%	0.30%	39.93%	35.52%	7.94%	6.88%	-0.018649	0.01%	4.41%	1.06%
88	16	64	4	2048	0.118172	0.040672	3.529026	4.673510	0.30%	0.29%	39.98%	35.54%	7.93%	6.87%	-0.077500	0.01%	4.44%	1.06%
89	16	64	16	256	0.000466	0.000432	0.067942	0.091320	0.50%	0.43%	39.32%	35.13%	8.02%	6.96%	-0.000034	0.07%	4.19%	1.06%
90	16	64	16	512	0.003623	0.001752	0.226667	0.308056	0.35%	0.30%	39.79%	35.43%	7.95%	6.87%	-0.001871	0.05%	4.36%	1.08%
91	16	64	16	1024	0.029350	0.008453	0.882770	1.199141	0.31%	0.27%	39.93%	35.52%	7.94%	6.85%	-0.020897	0.04%	4.41%	1.09%
92	16	64	16	2048	0.125417	0.041384	3.659078	4.795155	0.30%	0.26%	39.98%	35.54%	7.93%	6.85%	-0.084033	0.04%	4.44%	1.08%
93	16	64	32	256	0.000492	0.000460	0.072541	0.098155	0.50%	0.43%	39.30%	35.14%	8.02%	6.96%	-0.000032	0.07%	4.16%	1.06%
94	16	64	32	512	0.003798	0.001763	0.251732	0.328468	0.35%	0.30%	39.79%	35.43%	7.95%	6.87%	-0.002035	0.05%	4.36%	1.08%
95	16	64	32	1024	0.025407	0.008697	0.933484	1.278551	0.31%	0.27%	39.93%	35.52%	7.94%	6.85%	-0.016710	0.04%	4.41%	1.09%
96	16	64	32	2048	0.110608	0.039266	3.819582	5.098808	0.30%	0.26%	39.98%	35.54%	7.93%	6.85%	-0.071342	0.04%	4.44%	1.08%
97	32	8	4	256	0.000531	0.000430	0.069115	0.091125	3.33%	2.87%	39.70%	35.48%	10.37%	9.00%	-0.000101	0.46%	4.22%	1.37%
98	32	8	4	512	0.003730	0.001798	0.226999	0.304701	2.62%	2.25%	39.89%	35.52%	9.81%	8.48%	-0.001932	0.37%	4.37%	1.33%
99	32	8	4	1024	0.026724	0.009255	0.898623	1.185756	2.44%	2.10%	39.96%	35.54%	9.66%	8.34%	-0.017469	0.34%	4.42%	1.32%
100	32	8	4	2048	0.111935	0.041058	3.637126	4.750717	2.40%	2.06%	39.98%	35.55%	9.63%	8.31%	-0.070877	0.34%	4.43%	1.32%
101	32	8	16	256	0.000504	0.000480	0.070738	0.092484	3.33%	2.87%	39.70%	35.48%	10.37%	9.00%	-0.000024	0.46%	4.22%	1.37%
102	32	8	16	512	0.004095	0.001785	0.229668	0.311882	2.62%	2.25%	39.89%	35.52%	9.81%	8.48%	-0.002310	0.37%	4.37%	1.33%
103	32	8	16	1024	0.026749	0.009018	0.897657	1.214210	2.44%	2.10%	39.96%	35.54%	9.66%	8.34%	-0.017731	0.34%	4.42%	1.32%
104	32	8	16	2048	0.111899	0.040726	3.703847	4.875257	2.40%	2.06%	39.98%	35.55%	9.63%	8.31%	-0.071173	0.34%	4.43%	1.32%
105	32	8	32	256	0.000512	0.000426	0.075817	0.099226	3.33%	2.87%	39.70%	35.48%	10.37%	9.00%	-0.000086	0.46%	4.22%	1.37%
106	32	8	32	512	0.004160	0.001999	0.249046	0.330014	2.62%	2.25%	39.89%	35.52%	9.81%	8.48%	-0.002161	0.37%	4.37%	1.33%
107	32	8	32	1024	0.026748	0.008960	1.000414	1.298713	2.44%	2.10%	39.96%	35.54%	9.66%	8.34%	-0.017788	0.34%	4.42%	1.32%
108	32	8	32	2048	0.107763	0.041290	3.943303	5.246903	2.40%	2.06%	39.98%	35.55%	9.63%	8.31%	-0.066473	0.34%	4.43%	1.32%
109	32	16	4	256	0.000703	0.000423	0.068882	0.089261	1.78%	1.53%	39.51%	35.31%	9.08%	7.88%	-0.000280	0.25%	4.20%	1.20%
110	32	16	4	512	0.003773	0.001780	0.229465	0.303622	1.34%	1.15%	39.84%	35.48%	8.76%	7.57%	-0.001993	0.19%	4.36%	1.19%
111	32	16	4	1024	0.025383	0.009140	0.889962	1.183572	1.23%	1.05%	39.94%	35.53%	8.68%	7.50%	-0.016243	0.18%	4.41%	1.18%
112	32	16	4	2048	0.103569	0.041426	3.648602	4.776409	1.20%	1.03%	39.98%	35.54%	8.66%	7.48%	-0.062143	0.17%	4.44%	1.18%
113	32	16	16	256	0.000667	0.000474	0.067931	0.092325	1.77%	1.53%	39.51%	35.32%	9.08%	7.88%	-0.000193	0.24%	4.19%	1.20%
114	32	16	16	512	0.004270	0.001798	0.239441	0.309986	1.34%	1.15%	39.84%	35.48%	8.76%	7.57%	-0.002472	0.19%	4.36%	1.19%
115	32	16	16	1024	0.025475	0.008285	0.890945	1.211592	1.23%	1.05%	39.95%	35.53%	8.68%	7.50%	-0.017190	0.18%	4.42%	1.18%
116	32	16	16	2048	0.118258	0.044074	3.767684	4.824452	1.20%	1.03%	39.98%	35.55%	8.66%	7.48%	-0.074184	0.17%	4.43%	1.18%
117	32	16	32	256	0.000654	0.000431	0.071541	0.092450	1.77%	1.53%	39.51%	35.32%	9.08%	7.88%	-0.000223	0.24%	4.19%	1.20%
118	32	16	32	512	0.004193	0.001789	0.247927	0.331544	1.34%	1.15%	39.84%	35.48%	8.76%	7.57%	-0.002404	0.19%	4.36%	1.19%
119	32	16	32	1024	0.031574	0.009982	0.966932	1.289496	1.23%	1.05%	39.95%	35.53%	8.68%	7.50%	-0.021592	0.18%	4.42%	1.18%
120	32	16	32	2048	0.114668	0.042647	3.882766	5.163026	1.20%	1.03%	39.98%	35.55%	8.66%	7.48%	-0.072021	0.17%	4.43%	1.18%
121	32	32	4	256	0.000606	0.000434	0.067323	0.089495	0.92%	0.79%	39.38%	35.20%	8.37%	7.26%	-0.000172	0.13%	4.18%	1.11%
122	32	32	4	512	0.003645	0.001764	0.225899	0.303632	0.68%	0.58%	39.81%	35.45%	8.22%	7.11%	-0.001881	0.10%	4.36%	1.11%
123	32	32	4	1024	0.026460	0.008080	0.857972	1.183056	0.62%	0.53%	39.94%	35.52%	8.18%	7.07%	-0.018380	0.09%	4.42%	1.11%
124	32	32	4	2048	0.110254	0.043016	3.529225	4.679571	0.60%	0.52%	39.98%	35.54%	8.18%	7.06%	-0.067238	0.08%	4.44%	1.12%
125	32	32	16	256	0.000520	0.000423	0.068637	0.092170	0.92%	0.79%	39.38%	35.20%	8.37%	7.26%	-0.000097	0.13%	4.18%	1.11%
126	32	32	16	512	0.004215	0.001816	0.230962	0.310564	0.68%	0.58%	39.81%	35.45%	8.22%	7.11%	-0.002399	0.10%	4.36%	1.11%
127	32	32	16	1024	0.027075	0.008950	0.885976	1.204362	0.62%	0.53%	39.94%	35.52%	8.18%	7.07%	-0.018125	0.09%	4.42%	1.11%
128	32	32	16	2048	0.118992	0.040594	3.660125	4.813535	0.60%	0.52%	39.98%	35.54%	8.18%	7.06%	-0.078398	0.08%	4.44%	1.12%
129	32	32	32	256	0.000666	0.000423	0.074146	0.099529	0.92%	0.79%	39.38%	35.20%	8.37%	7.26%	-0.000243	0.13%	4.18%	1.11%

130	32	32	32	512	0.003736	0.001795	0.252357	0.330707	0.68%	0.58%	39.81%	35.45%	8.22%	7.11%	-0.001941	0.10%	4.36%	1.11%
131	32	32	32	1024	0.028435	0.008762	0.993879	1.284357	0.62%	0.53%	39.94%	35.52%	8.18%	7.07%	-0.019673	0.09%	4.42%	1.11%
132	32	32	32	2048	0.113204	0.039772	4.005329	5.134714	0.60%	0.52%	39.98%	35.54%	8.18%	7.06%	-0.073432	0.08%	4.44%	1.12%
133	32	64	4	256	0.000580	0.000471	0.066999	0.088517	0.49%	0.42%	39.31%	35.13%	8.01%	6.95%	-0.000109	0.07%	4.18%	1.06%
134	32	64	4	512	0.003877	0.001862	0.225366	0.302358	0.35%	0.30%	39.79%	35.43%	7.95%	6.87%	-0.002015	0.05%	4.36%	1.08%
135	32	64	4	1024	0.030612	0.009641	0.874387	1.190331	0.31%	0.27%	39.93%	35.52%	7.93%	6.85%	-0.020971	0.04%	4.41%	1.08%
136	32	64	4	2048	0.117066	0.039680	3.573482	4.669183	0.30%	0.27%	39.97%	35.54%	7.93%	6.86%	-0.077386	0.03%	4.43%	1.07%
137	32	64	16	256	0.000511	0.000433	0.069185	0.090613	0.49%	0.42%	39.30%	35.12%	8.00%	6.94%	-0.000078	0.07%	4.18%	1.06%
138	32	64	16	512	0.004153	0.001830	0.230643	0.314527	0.35%	0.30%	39.79%	35.43%	7.95%	6.87%	-0.002323	0.05%	4.36%	1.08%
139	32	64	16	1024	0.027429	0.009966	0.883880	1.206785	0.31%	0.27%	39.93%	35.52%	7.94%	6.85%	-0.017463	0.04%	4.41%	1.09%
140	32	64	16	2048	0.111414	0.040766	3.598662	4.773425	0.30%	0.26%	39.98%	35.54%	7.93%	6.85%	-0.070648	0.04%	4.44%	1.08%
141	32	64	32	256	0.000609	0.000436	0.070055	0.091766	0.49%	0.42%	39.30%	35.12%	8.00%	6.94%	-0.000173	0.07%	4.18%	1.06%
142	32	64	32	512	0.003961	0.001873	0.246427	0.326809	0.35%	0.30%	39.79%	35.43%	7.95%	6.87%	-0.002088	0.05%	4.36%	1.08%
143	32	64	32	1024	0.025979	0.011145	0.928577	1.276579	0.31%	0.27%	39.93%	35.52%	7.93%	6.85%	-0.014834	0.04%	4.41%	1.08%
144	32	64	32	2048	0.111359	0.039137	3.809517	5.141763	0.30%	0.26%	39.97%	35.54%	7.93%	6.85%	-0.072222	0.04%	4.43%	1.08%
145	64	8	4	256	0.000502	0.000442	0.067691	0.089298	3.29%	2.84%	39.63%	35.43%	10.33%	8.96%	-0.000060	0.45%	4.20%	1.37%
146	64	8	4	512	0.004091	0.001782	0.229634	0.304315	2.61%	2.24%	39.87%	35.51%	9.79%	8.47%	-0.002309	0.37%	4.36%	1.32%
147	64	8	4	1024	0.027755	0.010264	0.901472	1.185142	2.44%	2.09%	39.95%	35.54%	9.66%	8.34%	-0.017491	0.35%	4.41%	1.32%
148	64	8	4	2048	0.119388	0.040282	3.588899	4.843174	2.40%	2.05%	39.98%	35.55%	9.63%	8.31%	-0.079106	0.35%	4.43%	1.32%
149	64	8	16	256	0.000548	0.000442	0.070585	0.091996	3.29%	2.83%	39.62%	35.42%	10.32%	8.96%	-0.000106	0.46%	4.20%	1.36%
150	64	8	16	512	0.004222	0.001791	0.232126	0.311667	2.61%	2.24%	39.87%	35.50%	9.79%	8.47%	-0.002431	0.37%	4.37%	1.32%
151	64	8	16	1024	0.027367	0.008448	0.901882	1.219403	2.44%	2.09%	39.95%	35.54%	9.66%	8.34%	-0.018919	0.35%	4.41%	1.32%
152	64	8	16	2048	0.121061	0.041898	3.767084	4.886046	2.40%	2.05%	39.98%	35.55%	9.63%	8.31%	-0.079163	0.35%	4.43%	1.32%
153	64	8	32	256	0.000484	0.000428	0.076021	0.099885	3.29%	2.83%	39.62%	35.42%	10.32%	8.96%	-0.000056	0.46%	4.20%	1.36%
154	64	8	32	512	0.003649	0.001753	0.250820	0.326303	2.61%	2.24%	39.87%	35.50%	9.79%	8.47%	-0.001896	0.37%	4.37%	1.32%
155	64	8	32	1024	0.025343	0.008065	0.961591	1.302647	2.44%	2.09%	39.95%	35.54%	9.66%	8.34%	-0.017278	0.35%	4.41%	1.32%
156	64	8	32	2048	0.115441	0.042163	3.922954	5.197152	2.40%	2.05%	39.98%	35.55%	9.63%	8.31%	-0.073278	0.35%	4.43%	1.32%
157	64	16	4	256	0.000507	0.000477	0.068146	0.089136	1.75%	1.51%	39.47%	35.27%	9.06%	7.85%	-0.000030	0.24%	4.20%	1.21%
158	64	16	4	512	0.004189	0.001912	0.231996	0.305755	1.33%	1.15%	39.83%	35.46%	8.75%	7.57%	-0.002277	0.18%	4.37%	1.18%
159	64	16	4	1024	0.024928	0.008860	0.888593	1.187548	1.23%	1.05%	39.94%	35.53%	8.68%	7.49%	-0.016068	0.18%	4.41%	1.19%
160	64	16	4	2048	0.117076	0.040839	3.639464	4.745954	1.20%	1.03%	39.98%	35.54%	8.66%	7.47%	-0.076237	0.17%	4.44%	1.19%
161	64	16	16	256	0.000487	0.000422	0.066435	0.088671	1.75%	1.51%	39.44%	35.25%	9.05%	7.85%	-0.000065	0.24%	4.19%	1.20%
162	64	16	16	512	0.004140	0.001771	0.230719	0.309437	1.33%	1.14%	39.82%	35.46%	8.75%	7.56%	-0.002369	0.19%	4.36%	1.19%
163	64	16	16	1024	0.029203	0.008917	0.896807	1.209377	1.23%	1.05%	39.94%	35.52%	8.68%	7.49%	-0.020286	0.18%	4.42%	1.19%
164	64	16	16	2048	0.121130	0.040220	3.669374	4.823320	1.20%	1.03%	39.98%	35.54%	8.66%	7.47%	-0.080910	0.17%	4.44%	1.19%
165	64	16	32	256	0.000477	0.000431	0.066814	0.089373	1.75%	1.50%	39.43%	35.25%	9.04%	7.85%	-0.000046	0.25%	4.18%	1.19%
166	64	16	32	512	0.004331	0.001774	0.234748	0.315490	1.33%	1.14%	39.82%	35.46%	8.75%	7.56%	-0.002557	0.19%	4.36%	1.19%
167	64	16	32	1024	0.024499	0.009118	0.978976	1.293165	1.23%	1.05%	39.94%	35.52%	8.68%	7.49%	-0.015381	0.18%	4.42%	1.19%
168	64	16	32	2048	0.114838	0.039224	3.904724	5.178953	1.20%	1.03%	39.98%	35.54%	8.66%	7.47%	-0.075614	0.17%	4.44%	1.19%
169	64	32	4	256	0.000545	0.000475	0.068430	0.088614	0.90%	0.78%	39.35%	35.17%	8.35%	7.24%	-0.000070	0.12%	4.18%	1.11%
170	64	32	4	512	0.004336	0.001744	0.225102	0.301982	0.67%	0.58%	39.80%	35.44%	8.21%	7.10%	-0.002592	0.09%	4.36%	1.11%
171	64	32	4	1024	0.028650	0.009056	0.877210	1.175662	0.62%	0.53%	39.93%	35.52%	8.18%	7.06%	-0.019594	0.09%	4.41%	1.12%
172	64	32	4	2048	0.115070	0.041834	3.666079	4.742909	0.60%	0.52%	39.98%	35.54%	8.17%	7.06%	-0.073236	0.08%	4.44%	1.11%
173	64	32	16	256	0.000499	0.000439	0.068330	0.088429	0.90%	0.78%	39.33%	35.16%	8.34%	7.24%	-0.000060	0.12%	4.17%	1.10%
174	64	32	16	512	0.003891	0.001719	0.229174	0.308802	0.67%	0.58%	39.80%	35.44%	8.21%	7.10%	-0.002172	0.09%	4.36%	1.11%
175	64	32	16	1024	0.025596	0.008625	0.909262	1.203833	0.62%	0.53%	39.93%	35.52%	8.18%	7.06%	-0.016971	0.09%	4.41%	1.12%
176	64	32	16	2048	0.109731	0.039753	3.824846	4.877742	0.60%	0.52%	39.98%	35.54%	8.17%	7.06%	-0.069978	0.08%	4.44%	1.11%
177	64	32	32	256	0.000489	0.000471	0.069659	0.093990	0.90%	0.78%	39.33%	35.15%	8.34%	7.24%	-0.000018	0.12%	4.18%	1.10%
178	64	32	32	512	0.003742	0.001734	0.251763	0.320571	0.67%	0.58%	39.80%	35.44%	8.21%	7.10%	-0.002008	0.09%	4.36%	1.11%
179	64	32	32	1024	0.025524	0.008213	0.952666	1.278588	0.62%	0.53%	39.93%	35.52%	8.18%	7.06%	-0.017311	0.09%	4.41%	1.12%
180	64	32	32	2048	0.123592	0.040623	3.892393	5.914712	0.60%	0.51%	39.98%	35.54%	8.17%	7.06%	-0.082969	0.09%	4.44%	1.11%
181	64	64	1	256	0.000614	0.000465	0.064087	0.086626	0.50%	0.44%	39.38%	35.18%	8.03%	6.97%	-0.000149	0.06%	4.20%	1.06%
182	64	64	2	256	0.000496	0.000437	0.063760	0.087010	0.47%	0.41%	39.27%	35.11%	7.99%	6.93%	-0.000059	0.06%	4.16%	1.06%
183	64	64	4	256	0.000509	0.000488	0.066537	0.089853	0.47%	0.41%	39.28%	35.11%	7.99%	6.93%	-0.000021	0.06%	4.17%	1.06%
184	64	64	4	512	0.003841	0.001816	0.230320	0.302497	0.34%	0.29%	39.78%	35.42%	7.94%	6.87%	-0.002025	0.05%	4.36%	1.07%
185	64	64	4	1024	0.027569	0.009174	0.868874	1.184238	0.31%	0.27%	39.93%	35.52%	7.93%	6.85%	-0.018395	0.04%	4.41%	1.08%
186	64	64	4	2048	0.115359	0.039154	3.542714	4.695398	0.30%	0.26%	39.97%	35.54%	7.93%	6.85%	-0.076205	0.04%	4.43%	1.08%
187	64	64	8	256	0.000483	0.000461	0.067692	0.089952	0.47%	0.41%	39.28%	35.11%	7.99%	6.93%	-0.000022	0.06%	4.17%	1.06%
188	64	64	16	256	0.000488	0.000435	0.067852	0.093161	0.47%	0.41%	39.28%	35.11%	7.99%	6.93%	-0.000053	0.06%	4.17%	1.06%
189	64	64	16	512	0.003940	0.001899	0.227347	0.308676	0.34%	0.29%	39.78%	35.43%	7.94%	6.87%	-0.002041	0.05%	4.35%	1.07%
190	64	64	16	1024	0.025435	0.009329	0.874239	1.200219	0.31%	0.27%	39.93%	35.51%	7.93%	6.85%	-0.016106	0.04%	4.42%	1.08%
191	64	64	16	2048	0.110026	0.039192	3.597999	4.806836	0.30%	0.26%	39.97%	35.54%	7.93%	6.85%	-0.070834	0.04%	4.43%	1.08%
192	64	64	32	256	0.000642	0.000429	0.074060	0.096357	0.47%	0.41%	39.28%	35.11%	7.99%	6.93%	-0.000213	0.06%	4.17%	1.06%
193	64	64	32	512	0.003886	0.001804	0.259529	0.334428	0.34%	0.29%	39.78%	35.43%	7.94%	6.87%	-0.002082	0.05%	4.35%	1.07%
194	64	64	32	1024	0.028550	0.008849	0.959112	1.276098	0.31%	0.27%	39.93%	35.51%	7.93%	6.85%	-0.019701	0.04%	4.42%	1.08%

195	64	64	32	2048	0.124093	0.040481	3.866341	5.118490	0.30%	0.26%	39.97%	35.54%	7.93%	6.85%	-0.083612	0.04%	4.43%	1.08%
196	64	64	64	256	0.000535	0.000476	0.081077	0.109797	0.47%	0.41%	39.27%	35.10%	7.98%	6.93%	-0.000059	0.06%	4.17%	1.05%