**Operating System and CPU I am using:**

[hlong@royal-14] (1)$ lscpu

Architecture: x86\_64

CPU op-mode(s): 32-bit, 64-bit

Address sizes: 39 bits physical, 48 bits virtual

Byte Order: Little Endian

CPU(s): 12

On-line CPU(s) list: 0-11

Vendor ID: GenuineIntel

Model name: 11th Gen Intel(R) Core(TM) i5-11500 @ 2.70GHz

CPU family: 6

Model: 167

Thread(s) per core: 2

Core(s) per socket: 6

Socket(s): 1

Stepping: 1

CPU max MHz: 4600.0000

CPU min MHz: 800.0000

BogoMIPS: 5424.00

Flags: fpu vme de pse tsc msr pae mce cx8 apic sep mtrr pge mca cmov pat pse36 clflush dts acpi mmx fxsr sse sse2 ss ht tm pbe syscall nx pdpe1gb rdtscp lm constant\_tsc art arch\_per

fmon pebs bts rep\_good nopl xtopology nonstop\_tsc cpuid aperfmperf tsc\_known\_freq pni pclmulqdq dtes64 monitor ds\_cpl vmx smx est tm2 ssse3 sdbg fma cx16 xtpr pdcm pcid sse4\_

1 sse4\_2 x2apic movbe popcnt tsc\_deadline\_timer aes xsave avx f16c rdrand lahf\_lm abm 3dnowprefetch cpuid\_fault epb invpcid\_single ssbd ibrs ibpb stibp ibrs\_enhanced tpr\_shad

ow vnmi flexpriority ept vpid ept\_ad fsgsbase tsc\_adjust bmi1 avx2 smep bmi2 erms invpcid mpx avx512f avx512dq rdseed adx smap avx512ifma clflushopt intel\_pt avx512cd sha\_ni

avx512bw avx512vl xsaveopt xsavec xgetbv1 xsaves dtherm ida arat pln pts hwp hwp\_notify hwp\_act\_window hwp\_epp hwp\_pkg\_req avx512vbmi umip pku ospke avx512\_vbmi2 gfni vaes vp

clmulqdq avx512\_vnni avx512\_bitalg avx512\_vpopcntdq rdpid fsrm md\_clear flush\_l1d arch\_capabilities

Virtualization features:

Virtualization: VT-x

Caches (sum of all):

L1d: 288 KiB (6 instances)

L1i: 192 KiB (6 instances)

L2: 3 MiB (6 instances)

L3: 12 MiB (1 instance)

NUMA:

NUMA node(s): 1

NUMA node0 CPU(s): 0-11

Vulnerabilities:

Gather data sampling: Mitigation; Microcode

Itlb multihit: Not affected

L1tf: Not affected

Mds: Not affected

Meltdown: Not affected

Mmio stale data: Mitigation; Clear CPU buffers; SMT vulnerable

Retbleed: Mitigation; Enhanced IBRS

Spec rstack overflow: Not affected

Spec store bypass: Mitigation; Speculative Store Bypass disabled via prctl and seccomp

Spectre v1: Mitigation; usercopy/swapgs barriers and \_\_user pointer sanitization

Spectre v2: Mitigation; Enhanced IBRS, IBPB conditional, RSB filling, PBRSB-eIBRS SW sequence

Srbds: Not affected

Tsx async abort: Not affected

**How I compile the code:**

I first cd to the GEMM\_TEST\_0\_10 directory and ran this:

source /s/intelcompilers/bin/iccvars.sh intel64

icc \*.cpp -qopenmp -mkl -o output.exe

./output.exe

I have 12 cores in the computer lab machine.

**Here are the raw results of 18 timings:**

12 cores matrix size 1024 block size 32

Running candidate kernel for correctness test ... [Elapsed time : 15.374ms]

Running reference kernel for correctness test ... [Elapsed time : 26.7976ms]

Discrepancy between two methods : 8.01086e-05

Running kernel for performance run # 1 ... [Elapsed time : 14.4456ms]

Running kernel for performance run # 2 ... [Elapsed time : 13.7336ms]

Running kernel for performance run # 3 ... [Elapsed time : 13.7883ms]

Running kernel for performance run # 4 ... [Elapsed time : 13.8186ms]

Running kernel for performance run # 5 ... [Elapsed time : 13.8141ms]

Running kernel for performance run # 6 ... [Elapsed time : 13.8185ms]

Running kernel for performance run # 7 ... [Elapsed time : 13.7332ms]

Running kernel for performance run # 8 ... [Elapsed time : 13.7784ms]

Running kernel for performance run # 9 ... [Elapsed time : 13.8274ms]

Running kernel for performance run #10 ... [Elapsed time : 13.9666ms]

Running kernel for performance run #11 ... [Elapsed time : 13.7287ms]

Running kernel for performance run #12 ... [Elapsed time : 13.7651ms]

Running kernel for performance run #13 ... [Elapsed time : 13.8423ms]

Running kernel for performance run #14 ... [Elapsed time : 13.7783ms]

Running kernel for performance run #15 ... [Elapsed time : 14.4149ms]

Running kernel for performance run #16 ... [Elapsed time : 16.7686ms]

Running kernel for performance run #17 ... [Elapsed time : 13.7816ms]

Running kernel for performance run #18 ... [Elapsed time : 13.7708ms]

Running kernel for performance run #19 ... [Elapsed time : 13.7485ms]

Running kernel for performance run #20 ... [Elapsed time : 13.8039ms]

12 cores matrix size 2048 block size 32

Running candidate kernel for correctness test ... [Elapsed time : 116.427ms]

Running reference kernel for correctness test ... [Elapsed time : 70.061ms]

Discrepancy between two methods : 0.000152588

Running kernel for performance run # 1 ... [Elapsed time : 119.311ms]

Running kernel for performance run # 2 ... [Elapsed time : 119.678ms]

Running kernel for performance run # 3 ... [Elapsed time : 117.348ms]

Running kernel for performance run # 4 ... [Elapsed time : 118.52ms]

Running kernel for performance run # 5 ... [Elapsed time : 119.459ms]

Running kernel for performance run # 6 ... [Elapsed time : 117.71ms]

Running kernel for performance run # 7 ... [Elapsed time : 122.69ms]

Running kernel for performance run # 8 ... [Elapsed time : 116.766ms]

Running kernel for performance run # 9 ... [Elapsed time : 118.75ms]

Running kernel for performance run #10 ... [Elapsed time : 118.401ms]

Running kernel for performance run #11 ... [Elapsed time : 118.697ms]

Running kernel for performance run #12 ... [Elapsed time : 120.474ms]

Running kernel for performance run #13 ... [Elapsed time : 134.67ms]

Running kernel for performance run #14 ... [Elapsed time : 118.722ms]

Running kernel for performance run #15 ... [Elapsed time : 118.396ms]

Running kernel for performance run #16 ... [Elapsed time : 117.908ms]

Running kernel for performance run #17 ... [Elapsed time : 118.511ms]

Running kernel for performance run #18 ... [Elapsed time : 119.327ms]

Running kernel for performance run #19 ... [Elapsed time : 115.567ms]

Running kernel for performance run #20 ... [Elapsed time : 134.024ms]

12 cores matrix size 4096 block size 32

Running candidate kernel for correctness test ... [Elapsed time : 1110.45ms]

Running reference kernel for correctness test ... [Elapsed time : 373.674ms]

Discrepancy between two methods : 0.000362396

Running kernel for performance run # 1 ... [Elapsed time : 1048.1ms]

Running kernel for performance run # 2 ... [Elapsed time : 1081.49ms]

Running kernel for performance run # 3 ... [Elapsed time : 951.151ms]

Running kernel for performance run # 4 ... [Elapsed time : 1083.65ms]

Running kernel for performance run # 5 ... [Elapsed time : 943.575ms]

Running kernel for performance run # 6 ... [Elapsed time : 1019.39ms]

Running kernel for performance run # 7 ... [Elapsed time : 937.319ms]

Running kernel for performance run # 8 ... [Elapsed time : 964.815ms]

Running kernel for performance run # 9 ... [Elapsed time : 979.297ms]

Running kernel for performance run #10 ... [Elapsed time : 960.896ms]

Running kernel for performance run #11 ... [Elapsed time : 1150.39ms]

Running kernel for performance run #12 ... [Elapsed time : 982.919ms]

Running kernel for performance run #13 ... [Elapsed time : 1028.78ms]

Running kernel for performance run #14 ... [Elapsed time : 971.643ms]

Running kernel for performance run #15 ... [Elapsed time : 1028.91ms]

Running kernel for performance run #16 ... [Elapsed time : 986.622ms]

Running kernel for performance run #17 ... [Elapsed time : 1102.19ms]

Running kernel for performance run #18 ... [Elapsed time : 1193.94ms]

Running kernel for performance run #19 ... [Elapsed time : 1168.9ms]

Running kernel for performance run #20 ... [Elapsed time : 1207.57ms]

12 cores matrix size 1024 block size 64

Running candidate kernel for correctness test ... [Elapsed time : 21.9575ms]

Running reference kernel for correctness test ... [Elapsed time : 31.27ms]

Discrepancy between two methods : 8.01086e-05

Running kernel for performance run # 1 ... [Elapsed time : 20.8247ms]

Running kernel for performance run # 2 ... [Elapsed time : 20.3616ms]

Running kernel for performance run # 3 ... [Elapsed time : 20.5108ms]

Running kernel for performance run # 4 ... [Elapsed time : 20.6115ms]

Running kernel for performance run # 5 ... [Elapsed time : 20.3413ms]

Running kernel for performance run # 6 ... [Elapsed time : 20.6925ms]

Running kernel for performance run # 7 ... [Elapsed time : 20.4467ms]

Running kernel for performance run # 8 ... [Elapsed time : 20.4181ms]

Running kernel for performance run # 9 ... [Elapsed time : 20.4573ms]

Running kernel for performance run #10 ... [Elapsed time : 20.43ms]

Running kernel for performance run #11 ... [Elapsed time : 20.3923ms]

Running kernel for performance run #12 ... [Elapsed time : 20.4685ms]

Running kernel for performance run #13 ... [Elapsed time : 20.7098ms]

Running kernel for performance run #14 ... [Elapsed time : 20.5284ms]

Running kernel for performance run #15 ... [Elapsed time : 20.6534ms]

Running kernel for performance run #16 ... [Elapsed time : 20.509ms]

Running kernel for performance run #17 ... [Elapsed time : 20.4287ms]

Running kernel for performance run #18 ... [Elapsed time : 23.8518ms]

Running kernel for performance run #19 ... [Elapsed time : 20.5587ms]

Running kernel for performance run #20 ... [Elapsed time : 20.5357ms]

12 cores matrix size 2048 block size 64

Running candidate kernel for correctness test ... [Elapsed time : 155.31ms]

Running reference kernel for correctness test ... [Elapsed time : 76.0693ms]

Discrepancy between two methods : 0.000198364

Running kernel for performance run # 1 ... [Elapsed time : 161.435ms]

Running kernel for performance run # 2 ... [Elapsed time : 154.94ms]

Running kernel for performance run # 3 ... [Elapsed time : 156.184ms]

Running kernel for performance run # 4 ... [Elapsed time : 157.812ms]

Running kernel for performance run # 5 ... [Elapsed time : 156.981ms]

Running kernel for performance run # 6 ... [Elapsed time : 153.751ms]

Running kernel for performance run # 7 ... [Elapsed time : 156.827ms]

Running kernel for performance run # 8 ... [Elapsed time : 155.018ms]

Running kernel for performance run # 9 ... [Elapsed time : 157.666ms]

Running kernel for performance run #10 ... [Elapsed time : 156.909ms]

Running kernel for performance run #11 ... [Elapsed time : 157.451ms]

Running kernel for performance run #12 ... [Elapsed time : 156.145ms]

Running kernel for performance run #13 ... [Elapsed time : 157.562ms]

Running kernel for performance run #14 ... [Elapsed time : 171.103ms]

Running kernel for performance run #15 ... [Elapsed time : 164.77ms]

Running kernel for performance run #16 ... [Elapsed time : 156.369ms]

Running kernel for performance run #17 ... [Elapsed time : 157.027ms]

Running kernel for performance run #18 ... [Elapsed time : 156.856ms]

Running kernel for performance run #19 ... [Elapsed time : 156.354ms]

Running kernel for performance run #20 ... [Elapsed time : 157.241ms]

12 cores matrix size 4096 block size 64

Running candidate kernel for correctness test ... [Elapsed time : 1552.99ms]

Running reference kernel for correctness test ... [Elapsed time : 342.937ms]

Discrepancy between two methods : 0.000362396

Running kernel for performance run # 1 ... [Elapsed time : 1530.04ms]

Running kernel for performance run # 2 ... [Elapsed time : 1744.82ms]

Running kernel for performance run # 3 ... [Elapsed time : 1682.37ms]

Running kernel for performance run # 4 ... [Elapsed time : 1601.05ms]

Running kernel for performance run # 5 ... [Elapsed time : 2482.57ms]

Running kernel for performance run # 6 ... [Elapsed time : 2260.23ms]

Running kernel for performance run # 7 ... [Elapsed time : 2078.65ms]

Running kernel for performance run # 8 ... [Elapsed time : 2164.37ms]

Running kernel for performance run # 9 ... [Elapsed time : 2232.18ms]

Running kernel for performance run #10 ... [Elapsed time : 2123.86ms]

Running kernel for performance run #11 ... [Elapsed time : 2177.95ms]

Running kernel for performance run #12 ... [Elapsed time : 2189.86ms]

Running kernel for performance run #13 ... [Elapsed time : 2083.38ms]

Running kernel for performance run #14 ... [Elapsed time : 1813.35ms]

Running kernel for performance run #15 ... [Elapsed time : 1694.93ms]

Running kernel for performance run #16 ... [Elapsed time : 1685.09ms]

Running kernel for performance run #17 ... [Elapsed time : 1693.67ms]

Running kernel for performance run #18 ... [Elapsed time : 1675.93ms]

Running kernel for performance run #19 ... [Elapsed time : 1638.05ms]

Running kernel for performance run #20 ... [Elapsed time : 1695.2ms]

12 cores matrix size 1024 block size 128

Running candidate kernel for correctness test ... [Elapsed time : 27.4185ms]

Running reference kernel for correctness test ... [Elapsed time : 25.2149ms]

Discrepancy between two methods : 6.48499e-05

Running kernel for performance run # 1 ... [Elapsed time : 26.2627ms]

Running kernel for performance run # 2 ... [Elapsed time : 26.1839ms]

Running kernel for performance run # 3 ... [Elapsed time : 26.19ms]

Running kernel for performance run # 4 ... [Elapsed time : 26.0909ms]

Running kernel for performance run # 5 ... [Elapsed time : 25.4186ms]

Running kernel for performance run # 6 ... [Elapsed time : 25.8708ms]

Running kernel for performance run # 7 ... [Elapsed time : 25.7364ms]

Running kernel for performance run # 8 ... [Elapsed time : 25.7368ms]

Running kernel for performance run # 9 ... [Elapsed time : 25.5832ms]

Running kernel for performance run #10 ... [Elapsed time : 25.7632ms]

Running kernel for performance run #11 ... [Elapsed time : 26.6631ms]

Running kernel for performance run #12 ... [Elapsed time : 25.8328ms]

Running kernel for performance run #13 ... [Elapsed time : 25.8777ms]

Running kernel for performance run #14 ... [Elapsed time : 25.93ms]

Running kernel for performance run #15 ... [Elapsed time : 25.9495ms]

Running kernel for performance run #16 ... [Elapsed time : 25.9509ms]

Running kernel for performance run #17 ... [Elapsed time : 25.8908ms]

Running kernel for performance run #18 ... [Elapsed time : 26.6035ms]

Running kernel for performance run #19 ... [Elapsed time : 25.7922ms]

Running kernel for performance run #20 ... [Elapsed time : 25.7426ms]

12 cores matrix size 2048 block size 128

Running candidate kernel for correctness test ... [Elapsed time : 217.548ms]

Running reference kernel for correctness test ... [Elapsed time : 71.0272ms]

Discrepancy between two methods : 0.000156403

Running kernel for performance run # 1 ... [Elapsed time : 219.348ms]

Running kernel for performance run # 2 ... [Elapsed time : 217.24ms]

Running kernel for performance run # 3 ... [Elapsed time : 218.613ms]

Running kernel for performance run # 4 ... [Elapsed time : 214.341ms]

Running kernel for performance run # 5 ... [Elapsed time : 217.78ms]

Running kernel for performance run # 6 ... [Elapsed time : 220.693ms]

Running kernel for performance run # 7 ... [Elapsed time : 218.335ms]

Running kernel for performance run # 8 ... [Elapsed time : 218.938ms]

Running kernel for performance run # 9 ... [Elapsed time : 222.865ms]

Running kernel for performance run #10 ... [Elapsed time : 199.136ms]

Running kernel for performance run #11 ... [Elapsed time : 216.958ms]

Running kernel for performance run #12 ... [Elapsed time : 180.952ms]

Running kernel for performance run #13 ... [Elapsed time : 179.099ms]

Running kernel for performance run #14 ... [Elapsed time : 190.696ms]

Running kernel for performance run #15 ... [Elapsed time : 191.49ms]

Running kernel for performance run #16 ... [Elapsed time : 177.596ms]

Running kernel for performance run #17 ... [Elapsed time : 178.067ms]

Running kernel for performance run #18 ... [Elapsed time : 178.244ms]

Running kernel for performance run #19 ... [Elapsed time : 191.412ms]

Running kernel for performance run #20 ... [Elapsed time : 178.065ms]

12 cores matrix size 4096 block size 128

Running candidate kernel for correctness test ... [Elapsed time : 1391.36ms]

Running reference kernel for correctness test ... [Elapsed time : 292.72ms]

Discrepancy between two methods : 0.00037384

Running kernel for performance run # 1 ... [Elapsed time : 1368.46ms]

Running kernel for performance run # 2 ... [Elapsed time : 1442.2ms]

Running kernel for performance run # 3 ... [Elapsed time : 1355.01ms]

Running kernel for performance run # 4 ... [Elapsed time : 1369.19ms]

Running kernel for performance run # 5 ... [Elapsed time : 1358.61ms]

Running kernel for performance run # 6 ... [Elapsed time : 1361.79ms]

Running kernel for performance run # 7 ... [Elapsed time : 1378.52ms]

Running kernel for performance run # 8 ... [Elapsed time : 2039.6ms]

Running kernel for performance run # 9 ... [Elapsed time : 1669.04ms]

Running kernel for performance run #10 ... [Elapsed time : 1656.21ms]

Running kernel for performance run #11 ... [Elapsed time : 1668.04ms]

Running kernel for performance run #12 ... [Elapsed time : 1653.15ms]

Running kernel for performance run #13 ... [Elapsed time : 1682.11ms]

Running kernel for performance run #14 ... [Elapsed time : 1671.46ms]

Running kernel for performance run #15 ... [Elapsed time : 1661.03ms]

Running kernel for performance run #16 ... [Elapsed time : 1693.45ms]

Running kernel for performance run #17 ... [Elapsed time : 1677.72ms]

Running kernel for performance run #18 ... [Elapsed time : 1661.08ms]

Running kernel for performance run #19 ... [Elapsed time : 1660.18ms]

Running kernel for performance run #20 ... [Elapsed time : 1689.08ms]

1 core matrix size 1024 block size 32

Running candidate kernel for correctness test ... [Elapsed time : 78.5717ms]

Running reference kernel for correctness test ... [Elapsed time : 36.6755ms]

Discrepancy between two methods : 8.01086e-05

Running kernel for performance run # 1 ... [Elapsed time : 70.5964ms]

Running kernel for performance run # 2 ... [Elapsed time : 71.6318ms]

Running kernel for performance run # 3 ... [Elapsed time : 71.3244ms]

Running kernel for performance run # 4 ... [Elapsed time : 74.8986ms]

Running kernel for performance run # 5 ... [Elapsed time : 73.1602ms]

Running kernel for performance run # 6 ... [Elapsed time : 73.8578ms]

Running kernel for performance run # 7 ... [Elapsed time : 68.9249ms]

Running kernel for performance run # 8 ... [Elapsed time : 68.5564ms]

Running kernel for performance run # 9 ... [Elapsed time : 70.9707ms]

Running kernel for performance run #10 ... [Elapsed time : 68.818ms]

Running kernel for performance run #11 ... [Elapsed time : 68.6674ms]

Running kernel for performance run #12 ... [Elapsed time : 68.3754ms]

Running kernel for performance run #13 ... [Elapsed time : 72.3479ms]

Running kernel for performance run #14 ... [Elapsed time : 74.8973ms]

Running kernel for performance run #15 ... [Elapsed time : 71.4649ms]

Running kernel for performance run #16 ... [Elapsed time : 68.9649ms]

Running kernel for performance run #17 ... [Elapsed time : 68.4248ms]

Running kernel for performance run #18 ... [Elapsed time : 68.4871ms]

Running kernel for performance run #19 ... [Elapsed time : 79.4305ms]

Running kernel for performance run #20 ... [Elapsed time : 71.9172ms]

1 core matrix size 2048 block size 32

Running candidate kernel for correctness test ... [Elapsed time : 692.122ms]

Running reference kernel for correctness test ... [Elapsed time : 149.417ms]

Discrepancy between two methods : 0.000164032

Running kernel for performance run # 1 ... [Elapsed time : 685.349ms]

Running kernel for performance run # 2 ... [Elapsed time : 681.849ms]

Running kernel for performance run # 3 ... [Elapsed time : 703.534ms]

Running kernel for performance run # 4 ... [Elapsed time : 692.446ms]

Running kernel for performance run # 5 ... [Elapsed time : 683.227ms]

Running kernel for performance run # 6 ... [Elapsed time : 687.294ms]

Running kernel for performance run # 7 ... [Elapsed time : 679.897ms]

Running kernel for performance run # 8 ... [Elapsed time : 689.568ms]

Running kernel for performance run # 9 ... [Elapsed time : 718.404ms]

Running kernel for performance run #10 ... [Elapsed time : 759.087ms]

Running kernel for performance run #11 ... [Elapsed time : 710.325ms]

Running kernel for performance run #12 ... [Elapsed time : 693.168ms]

Running kernel for performance run #13 ... [Elapsed time : 687.093ms]

Running kernel for performance run #14 ... [Elapsed time : 681.53ms]

Running kernel for performance run #15 ... [Elapsed time : 688.422ms]

Running kernel for performance run #16 ... [Elapsed time : 680.712ms]

Running kernel for performance run #17 ... [Elapsed time : 688.48ms]

Running kernel for performance run #18 ... [Elapsed time : 701.831ms]

Running kernel for performance run #19 ... [Elapsed time : 687.619ms]

Running kernel for performance run #20 ... [Elapsed time : 685.347ms]

1 core matrix size 4096 block size 32

Running candidate kernel for correctness test ... [Elapsed time : 5717.26ms]

Running reference kernel for correctness test ... [Elapsed time : 1033ms]

Discrepancy between two methods : 0.000358582

Running kernel for performance run # 1 ... [Elapsed time : 5749.77ms]

Running kernel for performance run # 2 ... [Elapsed time : 5671.27ms]

Running kernel for performance run # 3 ... [Elapsed time : 5566.49ms]

Running kernel for performance run # 4 ... [Elapsed time : 5721.67ms]

Running kernel for performance run # 5 ... [Elapsed time : 5652.18ms]

Running kernel for performance run # 6 ... [Elapsed time : 5556.04ms]

Running kernel for performance run # 7 ... [Elapsed time : 5576.71ms]

Running kernel for performance run # 8 ... [Elapsed time : 5560.01ms]

Running kernel for performance run # 9 ... [Elapsed time : 5564.63ms]

Running kernel for performance run #10 ... [Elapsed time : 5567.45ms]

Running kernel for performance run #11 ... [Elapsed time : 5578.04ms]

Running kernel for performance run #12 ... [Elapsed time : 5567.54ms]

Running kernel for performance run #13 ... [Elapsed time : 5548.17ms]

Running kernel for performance run #14 ... [Elapsed time : 5559.28ms]

Running kernel for performance run #15 ... [Elapsed time : 5561.92ms]

Running kernel for performance run #16 ... [Elapsed time : 5557.71ms]

Running kernel for performance run #17 ... [Elapsed time : 5568.12ms]

Running kernel for performance run #18 ... [Elapsed time : 5581.87ms]

Running kernel for performance run #19 ... [Elapsed time : 5560.55ms]

Running kernel for performance run #20 ... [Elapsed time : 5551.84ms]

1 core matrix size 1024 block size 64

Running candidate kernel for correctness test ... [Elapsed time : 89.9028ms]

Running reference kernel for correctness test ... [Elapsed time : 38.8533ms]

Discrepancy between two methods : 7.82013e-05

Running kernel for performance run # 1 ... [Elapsed time : 87.9064ms]

Running kernel for performance run # 2 ... [Elapsed time : 87.8123ms]

Running kernel for performance run # 3 ... [Elapsed time : 87.1962ms]

Running kernel for performance run # 4 ... [Elapsed time : 87.4415ms]

Running kernel for performance run # 5 ... [Elapsed time : 87.9595ms]

Running kernel for performance run # 6 ... [Elapsed time : 87.731ms]

Running kernel for performance run # 7 ... [Elapsed time : 87.4513ms]

Running kernel for performance run # 8 ... [Elapsed time : 87.0165ms]

Running kernel for performance run # 9 ... [Elapsed time : 87.2351ms]

Running kernel for performance run #10 ... [Elapsed time : 94.959ms]

Running kernel for performance run #11 ... [Elapsed time : 97.0245ms]

Running kernel for performance run #12 ... [Elapsed time : 87.5301ms]

Running kernel for performance run #13 ... [Elapsed time : 87.1674ms]

Running kernel for performance run #14 ... [Elapsed time : 87.2476ms]

Running kernel for performance run #15 ... [Elapsed time : 87.1691ms]

Running kernel for performance run #16 ... [Elapsed time : 88.1091ms]

Running kernel for performance run #17 ... [Elapsed time : 88.6359ms]

Running kernel for performance run #18 ... [Elapsed time : 87.367ms]

Running kernel for performance run #19 ... [Elapsed time : 88.3124ms]

Running kernel for performance run #20 ... [Elapsed time : 87.3315ms]

1 core matrix size 2048 block size 64

Running candidate kernel for correctness test ... [Elapsed time : 767.813ms]

Running reference kernel for correctness test ... [Elapsed time : 148.913ms]

Discrepancy between two methods : 0.000156403

Running kernel for performance run # 1 ... [Elapsed time : 758.925ms]

Running kernel for performance run # 2 ... [Elapsed time : 756.803ms]

Running kernel for performance run # 3 ... [Elapsed time : 773.622ms]

Running kernel for performance run # 4 ... [Elapsed time : 757.959ms]

Running kernel for performance run # 5 ... [Elapsed time : 760.805ms]

Running kernel for performance run # 6 ... [Elapsed time : 758.074ms]

Running kernel for performance run # 7 ... [Elapsed time : 753.586ms]

Running kernel for performance run # 8 ... [Elapsed time : 757.602ms]

Running kernel for performance run # 9 ... [Elapsed time : 761.824ms]

Running kernel for performance run #10 ... [Elapsed time : 756.251ms]

Running kernel for performance run #11 ... [Elapsed time : 773.221ms]

Running kernel for performance run #12 ... [Elapsed time : 753.14ms]

Running kernel for performance run #13 ... [Elapsed time : 761.768ms]

Running kernel for performance run #14 ... [Elapsed time : 753.702ms]

Running kernel for performance run #15 ... [Elapsed time : 757.772ms]

Running kernel for performance run #16 ... [Elapsed time : 771.287ms]

Running kernel for performance run #17 ... [Elapsed time : 753.259ms]

Running kernel for performance run #18 ... [Elapsed time : 755.783ms]

Running kernel for performance run #19 ... [Elapsed time : 761.641ms]

Running kernel for performance run #20 ... [Elapsed time : 751.564ms]

1 core matrix size 4096 block size 64

Running candidate kernel for correctness test ... [Elapsed time : 6591.12ms]

Running reference kernel for correctness test ... [Elapsed time : 1025.19ms]

Discrepancy between two methods : 0.000347137

Running kernel for performance run # 1 ... [Elapsed time : 6558.8ms]

Running kernel for performance run # 2 ... [Elapsed time : 6561.16ms]

Running kernel for performance run # 3 ... [Elapsed time : 6585.06ms]

Running kernel for performance run # 4 ... [Elapsed time : 6563.5ms]

Running kernel for performance run # 5 ... [Elapsed time : 6554.64ms]

Running kernel for performance run # 6 ... [Elapsed time : 6559.88ms]

Running kernel for performance run # 7 ... [Elapsed time : 6583.75ms]

Running kernel for performance run # 8 ... [Elapsed time : 6557.03ms]

Running kernel for performance run # 9 ... [Elapsed time : 6604.54ms]

Running kernel for performance run #10 ... [Elapsed time : 6561.37ms]

Running kernel for performance run #11 ... [Elapsed time : 6554.5ms]

Running kernel for performance run #12 ... [Elapsed time : 6568.24ms]

Running kernel for performance run #13 ... [Elapsed time : 6554.67ms]

Running kernel for performance run #14 ... [Elapsed time : 6558.13ms]

Running kernel for performance run #15 ... [Elapsed time : 6555.07ms]

Running kernel for performance run #16 ... [Elapsed time : 6554.39ms]

Running kernel for performance run #17 ... [Elapsed time : 6563.55ms]

Running kernel for performance run #18 ... [Elapsed time : 6564.9ms]

Running kernel for performance run #19 ... [Elapsed time : 6561.17ms]

Running kernel for performance run #20 ... [Elapsed time : 6555.66ms]

1 core matrix size 1024 block size 128

Running candidate kernel for correctness test ... [Elapsed time : 99.9412ms]

Running reference kernel for correctness test ... [Elapsed time : 36.2519ms]

Discrepancy between two methods : 6.86646e-05

Running kernel for performance run # 1 ... [Elapsed time : 98.5576ms]

Running kernel for performance run # 2 ... [Elapsed time : 97.8946ms]

Running kernel for performance run # 3 ... [Elapsed time : 98.926ms]

Running kernel for performance run # 4 ... [Elapsed time : 98.125ms]

Running kernel for performance run # 5 ... [Elapsed time : 98.3033ms]

Running kernel for performance run # 6 ... [Elapsed time : 101.227ms]

Running kernel for performance run # 7 ... [Elapsed time : 100.282ms]

Running kernel for performance run # 8 ... [Elapsed time : 97.9935ms]

Running kernel for performance run # 9 ... [Elapsed time : 100.614ms]

Running kernel for performance run #10 ... [Elapsed time : 97.7871ms]

Running kernel for performance run #11 ... [Elapsed time : 97.7284ms]

Running kernel for performance run #12 ... [Elapsed time : 97.7264ms]

Running kernel for performance run #13 ... [Elapsed time : 98.0725ms]

Running kernel for performance run #14 ... [Elapsed time : 108.98ms]

Running kernel for performance run #15 ... [Elapsed time : 104.671ms]

Running kernel for performance run #16 ... [Elapsed time : 98.1562ms]

Running kernel for performance run #17 ... [Elapsed time : 98.0205ms]

Running kernel for performance run #18 ... [Elapsed time : 100.173ms]

Running kernel for performance run #19 ... [Elapsed time : 98.8568ms]

Running kernel for performance run #20 ... [Elapsed time : 97.9078ms]

1 core matrix size 2048 block size 128

Running candidate kernel for correctness test ... [Elapsed time : 839.682ms]

Running reference kernel for correctness test ... [Elapsed time : 149.3ms]

Discrepancy between two methods : 0.000228882

Running kernel for performance run # 1 ... [Elapsed time : 821.88ms]

Running kernel for performance run # 2 ... [Elapsed time : 840.693ms]

Running kernel for performance run # 3 ... [Elapsed time : 825.589ms]

Running kernel for performance run # 4 ... [Elapsed time : 825.088ms]

Running kernel for performance run # 5 ... [Elapsed time : 847.902ms]

Running kernel for performance run # 6 ... [Elapsed time : 821.895ms]

Running kernel for performance run # 7 ... [Elapsed time : 827.478ms]

Running kernel for performance run # 8 ... [Elapsed time : 828.946ms]

Running kernel for performance run # 9 ... [Elapsed time : 831.276ms]

Running kernel for performance run #10 ... [Elapsed time : 825.961ms]

Running kernel for performance run #11 ... [Elapsed time : 830.333ms]

Running kernel for performance run #12 ... [Elapsed time : 829.795ms]

Running kernel for performance run #13 ... [Elapsed time : 821.705ms]

Running kernel for performance run #14 ... [Elapsed time : 828.205ms]

Running kernel for performance run #15 ... [Elapsed time : 822.526ms]

Running kernel for performance run #16 ... [Elapsed time : 823.386ms]

Running kernel for performance run #17 ... [Elapsed time : 835.611ms]

Running kernel for performance run #18 ... [Elapsed time : 820.316ms]

Running kernel for performance run #19 ... [Elapsed time : 829.669ms]

Running kernel for performance run #20 ... [Elapsed time : 820.815ms]

1 core matrix size 4096 block size 128

Running candidate kernel for correctness test ... [Elapsed time : 6755.33ms]

Running reference kernel for correctness test ... [Elapsed time : 1020.35ms]

Discrepancy between two methods : 0.000335693

Running kernel for performance run # 1 ... [Elapsed time : 6750.1ms]

Running kernel for performance run # 2 ... [Elapsed time : 6736.14ms]

Running kernel for performance run # 3 ... [Elapsed time : 6739.7ms]

Running kernel for performance run # 4 ... [Elapsed time : 6739.48ms]

Running kernel for performance run # 5 ... [Elapsed time : 6733.99ms]

Running kernel for performance run # 6 ... [Elapsed time : 6734.5ms]

Running kernel for performance run # 7 ... [Elapsed time : 6751.93ms]

Running kernel for performance run # 8 ... [Elapsed time : 6739.67ms]

Running kernel for performance run # 9 ... [Elapsed time : 6738.41ms]

Running kernel for performance run #10 ... [Elapsed time : 6751.33ms]

Running kernel for performance run #11 ... [Elapsed time : 6737.24ms]

Running kernel for performance run #12 ... [Elapsed time : 6737.94ms]

Running kernel for performance run #13 ... [Elapsed time : 6754.84ms]

Running kernel for performance run #14 ... [Elapsed time : 6735.39ms]

Running kernel for performance run #15 ... [Elapsed time : 6757.37ms]

Running kernel for performance run #16 ... [Elapsed time : 6738.52ms]

Running kernel for performance run #17 ... [Elapsed time : 6734.34ms]

Running kernel for performance run #18 ... [Elapsed time : 6748.48ms]

Running kernel for performance run #19 ... [Elapsed time : 6750.58ms]

Running kernel for performance run #20 ... [Elapsed time : 6736.67ms]

**Summarize in a single table:**

| Number | Matrix Size | Block Size | Cores | Performance |
| --- | --- | --- | --- | --- |
| 1 | 1024 | 32 | 12 | 15.374 |
| 2 | 2048 | 32 | 12 | 116.427 |
| 3 | 4096 | 32 | 12 | 1110.45 |
| 4 | 1024 | 64 | 12 | 21.9575 |
| 5 | 2048 | 64 | 12 | 155.31 |
| 6 | 4096 | 64 | 12 | 1552.99 |
| 7 | 1024 | 128 | 12 | 27.4185 |
| 8 | 2048 | 128 | 12 | 217.548 |
| 9 | 4096 | 128 | 12 | 1391.36 |
| 10 | 1024 | 32 | 1 | 78.5717 |
| 11 | 2048 | 32 | 1 | 692.122 |
| 12 | 4096 | 32 | 1 | 5717.26 |
| 13 | 1024 | 64 | 1 | 89.9028 |
| 14 | 2048 | 64 | 1 | 767.813 |
| 15 | 4096 | 64 | 1 | 6591.12 |
| 16 | 1024 | 128 | 1 | 99.9412 |
| 17 | 2048 | 128 | 1 | 839.682 |
| 18 | 4096 | 128 | 1 | 6755.33 |

**Does operating at certain (large or small) matrix sizes seem to make it less important what the size of blocks is (for performance)?**

It looks like as the matrix size increases, the block size has less impact on the performance. If we compare the performance between matrix size 1024 and 4096 using 12 cores, we will see that for 1024, the performance actually grows as the block size grows. But for 4096, the relationship between block size and performance is not linear as the other tests suggest.

The reason for this is twofold in my opinion. First as matrix size grows, the change of block size is a less significant change compared to matrix size. Therefore, it’s going to impact less due to the nature of magnitude.

Also, for a 4096 size of matrix, it has higher chances in overflowing the CPU registers, therefore the block size is less significant because the main cost is spent on memory access.

**Are you seeing the same changes in parameters such as block size *helping* performance in some resolutions and *hindering* performance in others?**

Yes. Like I mentioned earlier, for 12 cores and 4096 size of a matrix, the increase of the block size is actually helping with the performance from 64 to 128. While it’s hindering the performance from 32 to 64.

Since we are parallelizing over block-rows, if the block size is too large, we might have the problem where the block info cannot fit into a certain cache.

If the block size is too small, than we might be wasting bandwidth of a cache line.

**For some of the resolutions/block sizes in your experiment, are you witnessing speed-up that is not quite proportional with the number of cores used when using all vs. one thread?**

Yes. When switching between 1 core and 12 cores, it’s noted that the speed only get improved by 6x. This could be coming from the fact that there’s more overhead in syncing between cores and also in contention for shared resources like memory.