



SPEC ACCEL

A Standard Application Suite for Measuring Hardware Accelerator Performance

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Who is SPEC?

- SPEC is a non-profit corporation formed to "establish, maintain and endorse a standardized set of relevant benchmarks that can be applied to the newest generation of high-performance computers"
- Composed of four groups
 - Graphics and Workstation Performance Group (GWPG)
 - High Performance Group (HPG)
 - Open Systems Group (OSG)
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- www.spec.org



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SPEC Members:

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*Academia Sinica, Institute of Information Science * Austrian Energy Agency * Argonne National Laboratory * Charles University * Department of Veteran's Affairs - Corporate Data Center Operations * Dresden University of Technology ZIH * Indiana University * Institute for Information Industry Taiwan * JAIST * Karlsruhe Institute of Technology * Leibniz Rechenzentrum - Germany * MIT Lincoln Laboratory * National University of Singapore * Ohio State University * Pennsylvania State University * Purdue University * RWTH Aachen University * Technische Universität Darmstadt * Tsinghua University * University of Aizu - Japan * University of California - Berkeley * University of Cologne * University of Houston * University of Illinois at Urbana-Champaign * University of Maryland * University of Miami * University of Pavia * University of Texas at Austin * University of Tsukuba * Virginia Polytechnic Institute and State University **

SPEC High Performance Group (HPG)

- Develops benchmarks to represent high-performance computing applications for standardized, cross-platform performance evaluation.
- Benchmarks
 - SPEC OMP2012
 - SPEC MPI2007
 - SPEC ACCEL



- SPEC Accel provides a comparative performance measure of
 - Hardware Accelerator devices (GPU, Co-processors, etc.)
 - Supporting software tool chains (Compilers, Drivers, etc.)
 - Host systems and accelerator interface (CPU, PCIe, etc.)
- Computationally-intensive parallel High Performance Computing (HPC) applications, benchmarks, and mini-apps
- Portable across multiple accelerators
- Two distinct suites
 - OpenACC v1.0
 - OpenCL v1.1

SPEC ACCEL Users

- Users looking for objective apples-to-apples comparison
- System vendors
- Accelerator vendors
- Software vendors
- Researchers

- SPEC provides a standard methodology to measure and report power usage which can be incorporated into a SPEC benchmark.
- Normalizes the power usage across the full run of the suite

```
time,03-10-2014 14:14:25.304, Temperature, 25.187500, Humidity, 29.000000
time,03-10-2014 14:14:30.389, Temperature, 25.187500, Humidity, 29.000000
03-10-2014 14:14:52.251: go with mark '304.olbm'
03-10-2014 14:14:52.251: Response to client sent: Starting untimed measure
ex at 5000ms with 0 rampup samples
03-10-2014 14:14:54.548, Temp, 25.125000, Humidity, 29.000000, Mark, 304.olbm
03-10-2014 14:14:59.548, Temp, 25.125000, Humidity, 29.000000, Mark, 304.olbm
03-10-2014 14:15:04.949, Temp, 25.125000, Humidity, 29.000000, Mark, 304.olbm
03-10-2014 14:15:09.949, Temp, 25.125000, Humidity, 29.000000, Mark, 304.olbm
03-10-2014 14:15:14.949, Temp, 25.125000, Humidity, 29.000000, Mark, 304.olbm
03-10-2014 14:15:19.948, Temp, 25.187500, Humidity, 29.000000, Mark, 304.olbm
03-10-2014 14:15:24.949, Temp, 25.125000, Humidity, 29.000000, Mark, 304.olbm
03-10-2014 14:15:29.948, Temp, 25.187500, Humidity, 29.000000, Mark, 304.olbm
03-10-2014 14:15:34.948, Temp, 25.187500, Humidity, 29.000000, Mark, 304.olbm
03-10-2014 14:15:39.949, Temp, 25.187500, Humidity, 29.000000, Mark, 304.olbm
03-10-2014 14:15:44.948, Temp, 25.187500, Humidity, 29.000000, Mark, 304.olbm
03-10-2014 14:15:49.948, Temp, 25.187500, Humidity, 29.000000, Mark, 304.olbm
03-10-2014 14:15:54.948, Temp, 25.187500, Humidity, 29.000000, Mark, 304.olbm
03-10-2014 14:15:59.948, Temp, 25.187500, Humidity, 29.000000, Mark, 304.olbm
```



```
time,03-10-2014 14:14:26.428, Watts, 308.129000, Volts, 126.442000, Amps, 2.832000, Pp, 0.871682
time,03-10-2014 14:14:27.857, Watts, 308.126000, Volts, 126.533000, Amps, 2.832200, Pp, 0.871686
time,03-10-2014 14:14:29.408, Watts, 308.149000, Volts, 126.520000, Amps, 2.834000, Pp, 0.871682
time,03-10-2014 14:14:31.859, Watts, 308.149000, Volts, 126.530000, Amps, 2.834000, Pp, 0.871682
time,03-10-2014 14:14:34.857, Watts, 308.148000, Volts, 126.520000, Amps, 2.834000, Pp, 0.871682
03-10-2014 14:14:39.833: Response to client sent: Time, 03-10-2014 14:14:35.436, watts, 395.751000, Volts, 120.521000, Amps, 2.436000, Pp, 0.971045
time,03-10-2014 14:14:36.458, Watts, 308.834000, Volts, 126.530000, Amps, 2.837200, Pp, 0.871679
time,03-10-2014 14:14:37.857, Watts, 308.950000, Volts, 126.524000, Amps, 2.838100, Pp, 0.871677
time,03-10-2014 14:14:38.458, Watts, 308.862000, Volts, 126.520000, Amps, 2.838100, Pp, 0.871680
03-10-2014 14:14:52.250: go with mark '304.olbm'
03-10-2014 14:14:52.250: Response to client sent: Starting untimed measurement, max/min 50000 samples at 1000ms with 0 rampup samples
03-10-2014 14:14:52.747, Watts, 289.814000, Volts, 120.827000, Amps, 1.417400, Pp, 0.921700, Mark, 304.olbm
03-10-2014 14:14:53.746, Watts, 138.467000, Volts, 120.836000, Amps, 1.136560, Pp, 0.948820, Mark, 304.olbm
03-10-2014 14:14:54.747, Watts, 186.400000, Volts, 120.850000, Amps, 1.457490, Pp, 0.944520, Mark, 304.olbm
03-10-2014 14:14:55.747, Watts, 199.812000, Volts, 120.776000, Amps, 1.730290, Pp, 0.956115, Mark, 304.olbm
03-10-2014 14:14:56.746, Watts, 253.247000, Volts, 120.502000, Amps, 2.108000, Pp, 0.969000, Mark, 304.olbm
03-10-2014 14:14:57.747, Watts, 265.216000, Volts, 120.548000, Amps, 2.278210, Pp, 0.968100, Mark, 304.olbm
03-10-2014 14:14:59.747, Watts, 265.826000, Volts, 120.590000, Amps, 2.202400, Pp, 0.968100, Mark, 304.olbm
03-10-2014 14:14:59.746, Watts, 261.846000, Volts, 120.637000, Amps, 2.235970, Pp, 0.963600, Mark, 304.olbm
03-10-2014 14:15:00.747, Watts, 266.467000, Volts, 120.590000, Amps, 2.207400, Pp, 0.964000, Mark, 304.olbm
03-10-2014 14:15:01.747, Watts, 261.476000, Volts, 120.556000, Amps, 2.232190, Pp, 0.963600, Mark, 304.olbm
03-10-2014 14:15:02.746, Watts, 266.597000, Volts, 120.577000, Amps, 2.286200, Pp, 0.962659, Mark, 304.olbm
```

OpenCL Suite – Benchmarks Taken from Parboil

Benchmarks	Language	Application Domain
101.tpacf	C++	Astrophysics
103.stencil	C++	Thermodynamics
104.lbm	C++	Fluid Dynamics
110.fft	C	Signal processing
112.spmv	C++	Sparse Linear Algebra
114.mriq	C	Medicine
116.histo	C	Silicon Wafer Verification
117.bfs	C	Electronic Design Automation, Graph Traversals
118.cutcp	C	Molecular Dynamics

OpenCL Suite – Benchmarks Taken from Rodinia

Benchmarks	Language	Application Domain
120.kmeans	C++	Dense Linear Algebra, Data Mining
121.lavamd	C	N-Body, Molecular Dynamics
122.cfd	C++	Unstructured Grid, Fluid Dynamics
123.nw	C++	Dynamic Programming, Bioinformatics
124.hotspot	C	Structured Grid, Physics Simulation
125.lud	C++	Dense Linear Algebra, Linear Algebra
126.ge	C++	Gaussian Elimination
127.srad	C	Structured Grid, Image Processing
128.heartwall	C	Structured Grid, Medical Imaging
140.bplustree	C	Graph Traversal, Search

OpenACC Suite

OpenACC Benchmarks	Language	Origin	Application Domain
303.ostencil	C	Parboil, University of Illinois	Thermodynamics
304.olbm	C	Parboil, University of Illinois, SPEC CPU2006	Computational Fluid Dynamics, Lattice Boltzmann
314.omriq	C	Rodinia, University of Virginia	Medicine
350.md	Fortran	Indiana University	Molecular Dynamics
351.palm	Fortran	Leibniz University of Hannover	Large-eddy simulation, atmospheric turbulence
352.ep	C	NAS Parallel Benchmarks (NPB)	Embarrassingly Parallel
353.cvrleaf	C, Fortran	Atomic Weapons Establishment (AWE)	Explicit Hydrodynamics
354.cg	C	NPB	Conjugate Gradient Solver
355.seismic	Fortran	GeoDynamics.org, University of Pau	Seismic Wave Modeling (PDE)
356.sp	Fortran	NPB	Scalar Penta-diagonal solver
357.csp	C	NPB	Scalar Penta-diagonal solver
359.miniGhost	C, Fortran	Sandia National Lab	Finite difference
360.ilbdc	Fortran	SPEC OMP2012	Fluid Mechanics
363.swim	Fortran	SPEC OMP2012	Weather
370.bt	C	NPB	Block Tridiagonal Solver for 3D PDE

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Resources

- Kit Map
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- Kit Index
- Glossary
- Historical Links

The SPEC ACCEL™ V1.0 benchmark tests performance with a suite of OpenACC APIs. Support for the OpenMP 4.0 API for Accelerator, ACCFI™ benchmark measures the performance of the accelerator, compilers, and drivers. The SPEC ACCEL™ benchmark is available for a wide range of hardware configurations.

The benchmark suite contains 19 application benchmarks running on well-respected Parboil benchmarks from the IMPACT Research Group from the University of Virginia. The OpenACC suite includes tests from high-performance computing (HPC) applications.

Results

Submitted Results

Results for all of the SPEC ACCEL™ benchmark metrics. Includes other benchmarks of the benchmark.

Purchase the SPEC ACCEL™ software

The SPEC ACCEL™ benchmark software is available as a download from SPEC office for additional information.

Documentation

- Documentation overview
- System requirements
- Installation guide
- Explanation of the tests in a result dashboard
- Run and reporting rules
- Known issues

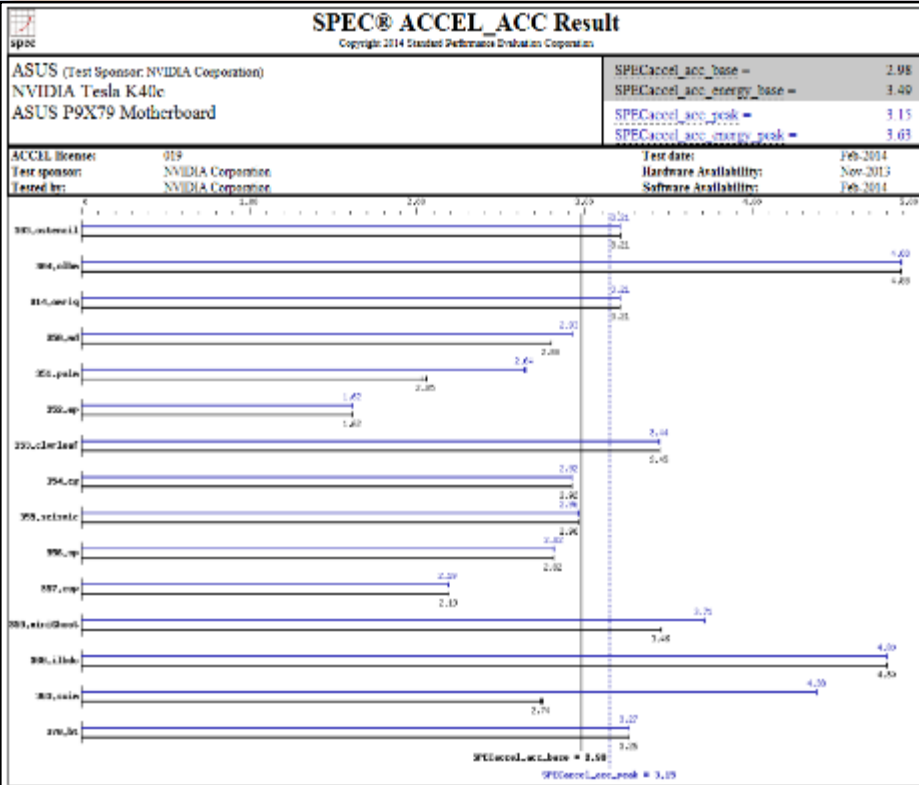
OpenACC (18):

Test Sponsor	System Name	Accelerator Name	Results		Energy	
			Base	Peak	Base	Peak
Indiana University	Cray XK7	NVIDIA Tesla K20	1.74	Not Run	--	--
Indiana University	Cray XK7	NVIDIA Tesla K20	1.27	Not Run	--	--
Indiana University	Cray XK7	NVIDIA Tesla K20	1.31	Not Run	--	--
Indiana University	Cray XK7	NVIDIA Tesla K20	1.77	Not Run	--	--
NVIDIA Corporation	ASUS P9X79 Motherboard	NVIDIA Tesla K40c	2.21	2.32	2.88	2.98
NVIDIA Corporation	ASUS P9X79 Motherboard	NVIDIA Tesla K40c	2.47	2.60	3.03	3.14
NVIDIA Corporation	ASUS P9X79 Motherboard	NVIDIA Tesla K40c	2.59	2.73	3.01	3.13
NVIDIA Corporation	ASUS P9X79 Motherboard	NVIDIA Tesla K40c	2.59	2.72	3.35	3.49
NVIDIA Corporation	ASUS P9X79 Motherboard	NVIDIA Tesla K40c	2.84	3.00	3.50	3.63
NVIDIA Corporation	ASUS P9X79 Motherboard	NVIDIA Tesla K40c	2.98	3.15	3.49	3.63
RWTH Aachen University	bulk R421-E3	NVIDIA Tesla K20Xm	2.00	Not Run	--	--
RWTH Aachen University	bulk R425-E2	NVIDIA Quadro 6000	1.05	Not Run	--	--

OpenCL (16):

Test Sponsor	System Name	Accelerator Name	Results		Energy	
			Base	Peak	Base	Peak
Technische Universität Dresden	SGI C3108-TY11	NVIDIA Tesla C2070	0.996	Not Run	0.997	--
Technische Universität Dresden	Precision T5600	AMD Radeon HD 7970	2.33	Not Run	3.75	--
Technische Universität Dresden	Precision T5600	NVIDIA Tesla K20c	1.68	Not Run	2.84	--
Technische Universität Dresden	Precision T5600	NVIDIA Tesla K20c	1.64	Not Run	2.77	--
Technische Universität Dresden	Precision T5600	NVIDIA Tesla K40c	1.91	Not Run	2.94	--
Technische Universität Dresden	Precision T5600	NVIDIA GeForce GTX TITAN	2.38	Not Run	2.94	--

A Single Result Explained



<h3 style="text-align: center;">Hardware</h3> <p>CPU Name: Intel Core i7-3930K CPU Characteristics: 3200 CPU MHz: 3500 CPU MHz Maximum: 3500 JPU: CPU(s) enabled: 6 cores, 1 chip, 6 cores/chip, 2 threads/core CPU(s) orderable: 1 chip Primary Cache: 12 KB L1 + 32 KB D on chip per core Secondary Cache: 256 KB 1=2 on chip per core</p>	<h3 style="text-align: center;">Accelerator</h3> <p>Accl Model Name: Tesla K40c Accl Vendor: NVIDIA Accl Name: NVIDIA Tesla K40c Type of Accl: GPU Accl Connection: PCIe 3.0 16n Does Accl Use ECC: No Accl Description: GPU Boost set to maximum graphic clock frequency of 672 MHz. See notes below. Accl Driver: NVIDIA LINUX x86_64 Kernel Module 310.60</p>
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Power

Power Supply: 1200 W
 Power Supply Details: Thermaltake SMART M1200W
 Max. Power (W): 398.64
 Idle Power (W): 94.87
 Min. Temperature (C): 26.56

Power Analyzer

Power Analyzer: Xitron Technologies, Inc.
 Model: 2801
 Serial Number: RS252 via USB adapter
 Input Connection: NIST
 Metrology Institute: Metro Precision Calibration, Inc.
 Calibration By: 220081222038459
 Calibration Date: 02.20.2014
 PTDaemon Version: 1.6.2 (372e138a; 2013-12-04)
 Setup Description: connected to the single power supply that powers the system

Temperature Meter

Temperature Meter: Digi
 Hardware Vendor: Digi/WATCHPORT_H
 Model: WS34682143
 Serial Number: USB
 Input Connection: FTDaemon Version: 1.6.2 (372e138a; 2013-12-04)
 Setup Description: Position 5mm above intake fan

Current Ranges Used: 2.0A
 Voltage Range Used: 135V

Base Results Table

Benchmark	Seconds	Rate	Energy (kJ)	Maximum Power	Average Power	Energy Ratio	Seconds	Rate	Energy (kJ)	Maximum Power	Average Power	Energy Ratio	Seconds	Rate	Energy (kJ)	Maximum Power	Average Power	Energy Ratio
303.ostencil	45.8	3.17	16.8	384	367	3.15	<u>45.7</u>	<u>3.17</u>	<u>16.6</u>	<u>374</u>	<u>364</u>	<u>3.18</u>	<u>45.8</u>	<u>3.17</u>	<u>16.8</u>	<u>375</u>	<u>366</u>	<u>3.16</u>
304.olbm	194	2.35	56.1	296	290	2.78	194	2.35	56.3	298	291	2.77	<u>194</u>	<u>2.35</u>	<u>56.1</u>	<u>299</u>	<u>300</u>	<u>2.78</u>
314.omniq	354	2.70	131	375	369	2.92	<u>354</u>	<u>2.70</u>	<u>131</u>	<u>375</u>	<u>371</u>	<u>2.91</u>	354	2.70	132	376	372	2.90
350.md	90.6	2.78	31.6	354	349	2.97	90.7	2.78	31.7	367	349	2.97	<u>90.7</u>	<u>2.78</u>	<u>31.6</u>	<u>363</u>	<u>349</u>	<u>2.97</u>
351.palm	<u>184</u>	<u>2.01</u>	<u>42.0</u>	<u>238</u>	<u>228</u>	<u>2.54</u>	189	1.96	43.1	237	228	2.48	184	2.01	42.0	241	228	2.55
352.ep	330	1.60	83.8	275	254	1.96	<u>330</u>	<u>1.61</u>	<u>83.9</u>	<u>256</u>	<u>254</u>	<u>1.96</u>	330	1.61	83.5	255	253	1.97
353.civleaf	145	3.07	46.0	322	317	3.42	145	3.07	45.9	322	317	3.43	<u>145</u>	<u>3.07</u>	<u>45.8</u>	<u>325</u>	<u>316</u>	<u>3.44</u>
354.cg	<u>144</u>	<u>2.84</u>	<u>41.5</u>	<u>328</u>	<u>289</u>	<u>3.37</u>	144	2.84	41.5	328	289	3.37	144	2.84	41.4	326	288	3.38
355.seismic	<u>133</u>	<u>2.79</u>	<u>38.2</u>	<u>298</u>	<u>288</u>	<u>3.38</u>	133	2.79	38.1	298	287	3.39	133	2.79	38.1	297	287	3.39
356.ep	118	2.35	33.9	292	288	2.74	<u>118</u>	<u>2.35</u>	<u>33.8</u>	<u>291</u>	<u>288</u>	<u>2.74</u>	118	2.35	33.8	291	287	2.74
357.csp	143	1.89	39.3	286	275	2.24	143	1.89	39.1	285	274	2.25	<u>143</u>	<u>1.89</u>	<u>39.2</u>	<u>288</u>	<u>275</u>	<u>2.25</u>
359.miniGhost	<u>132</u>	<u>2.80</u>	<u>37.0</u>	<u>304</u>	<u>281</u>	<u>3.21</u>	132	2.80	36.8	304	280	3.23	132	2.80	36.8	302	280	3.23
360.tbdc	<u>97.3</u>	<u>3.77</u>	<u>29.7</u>	<u>315</u>	<u>305</u>	<u>4.37</u>	97.3	3.77	29.6	314	305	4.38	97.4	3.77	29.7	314	305	4.38
363.svwm	88.7	2.59	23.5	266	265	3.23	88.4	2.60	23.4	265	264	3.25	<u>88.4</u>	<u>2.60</u>	<u>23.4</u>	<u>265</u>	<u>264</u>	<u>3.25</u>
370.bt	<u>75.7</u>	<u>2.95</u>	<u>21.3</u>	<u>284</u>	<u>281</u>	<u>3.56</u>	75.7	2.95	21.1	281	279	3.58	75.7	2.95	21.1	282	279	3.58

Results appear in the order in which they were run. Bold underlined text indicates a median measurement.

Peak Results Table

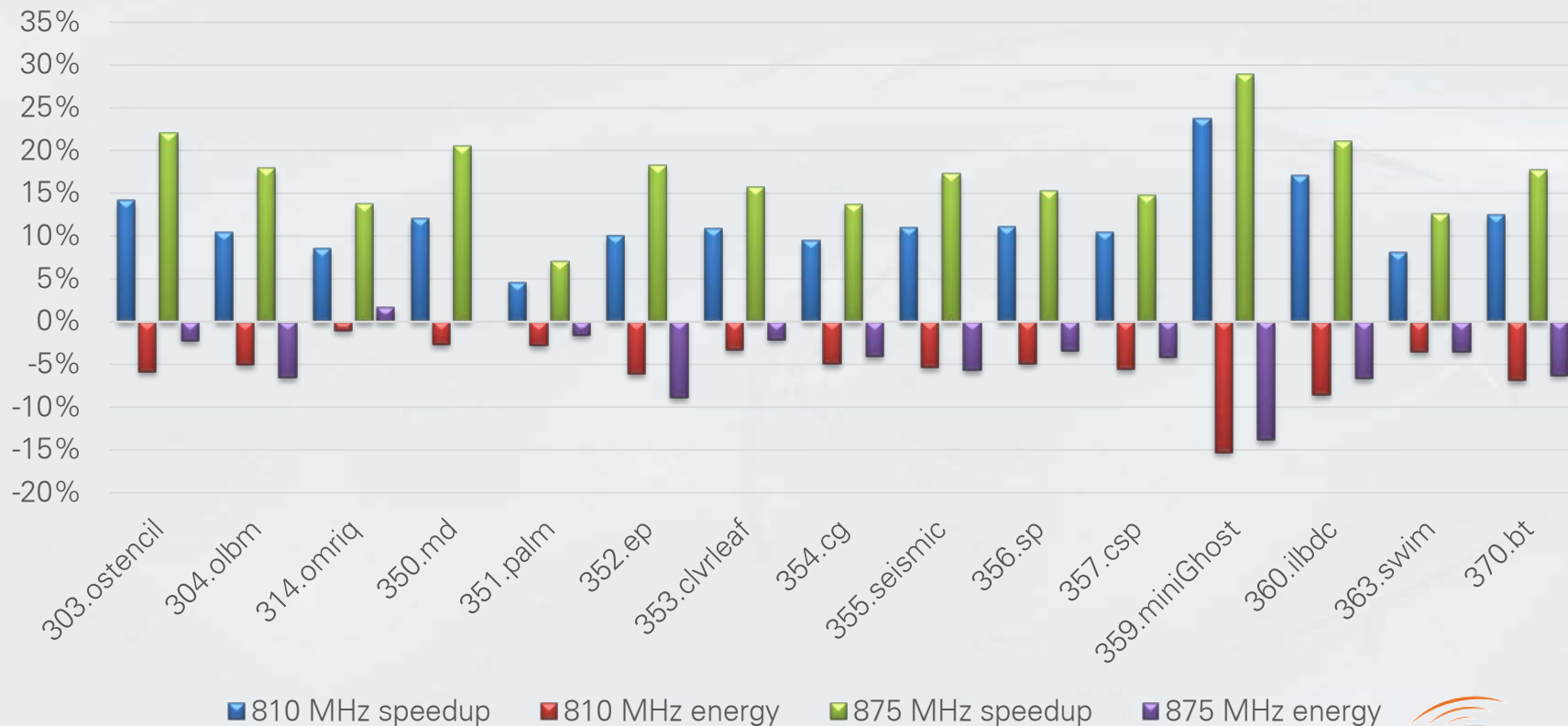
Benchmark	Seconds	Rate	Energy (kJ)	Maximum Power	Average Power	Energy Ratio	Seconds	Rate	Energy (kJ)	Maximum Power	Average Power	Energy Ratio	Seconds	Rate	Energy (kJ)	Maximum Power	Average Power	Energy Ratio
303.ostencil	45.7	3.17	16.8	373	366	3.16	<u>45.7</u>	<u>3.17</u>	<u>16.8</u>	<u>373</u>	<u>368</u>	<u>3.18</u>	<u>45.7</u>	<u>3.17</u>	<u>16.7</u>	<u>374</u>	<u>364</u>	<u>3.18</u>
304.olbm	<u>194</u>	<u>2.35</u>	<u>56.2</u>	<u>303</u>	<u>290</u>	<u>2.78</u>	194	2.35	56.0	295	289	2.79	194	2.35	56.0	295	289	2.79
314.omniq	354	2.70	131	375	370	2.92	354	2.70	131	399	371	2.92	<u>354</u>	<u>2.70</u>	<u>131</u>	<u>391</u>	<u>370</u>	<u>2.92</u>
350.md	86.7	2.91	31.0	364	358	3.03	86.7	2.91	31.1	365	359	3.02	<u>86.7</u>	<u>2.91</u>	<u>31.0</u>	<u>363</u>	<u>358</u>	<u>3.03</u>
351.palm	145	2.54	34.7	256	238	3.09	<u>145</u>	<u>2.55</u>	<u>34.6</u>	<u>251</u>	<u>239</u>	<u>3.09</u>	145	2.55	34.5	251	238	3.10
352.ep	<u>330</u>	<u>1.60</u>	<u>83.6</u>	<u>255</u>	<u>253</u>	<u>1.97</u>	330	1.61	83.8	272	254	1.96	330	1.60	83.9	273	254	1.96
353.civleaf	145	3.07	45.9	322	316	3.43	<u>145</u>	<u>3.07</u>	<u>45.6</u>	<u>322</u>	<u>315</u>	<u>3.45</u>	145	3.07	45.7	321	315	3.45
354.cg	144	2.84	41.5	328	288	3.38	144	2.84	41.5	339	289	3.38	<u>144</u>	<u>2.84</u>	<u>41.7</u>	<u>328</u>	<u>290</u>	<u>3.36</u>
355.seismic	133	2.79	38.1	297	287	3.39	133	2.79	38.2	297	288	3.38	<u>133</u>	<u>2.79</u>	<u>38.2</u>	<u>304</u>	<u>288</u>	<u>3.38</u>
356.ep	<u>118</u>	<u>2.35</u>	<u>33.7</u>	<u>291</u>	<u>287</u>	<u>2.75</u>	118	2.35	33.9	291	288	2.74	118	2.35	33.7	292	287	2.75
357.csp	143	1.89	39.2	278	274	2.25	143	1.89	39.1	278	274	2.25	<u>143</u>	<u>1.89</u>	<u>39.2</u>	<u>278</u>	<u>275</u>	<u>2.24</u>
359.miniGhost	<u>121</u>	<u>3.04</u>	<u>35.1</u>	<u>336</u>	<u>289</u>	<u>3.39</u>	121	3.04	35.1	339	289	3.39	121	3.04	35.2	333	290	3.38
360.tbdc	<u>97.3</u>	<u>3.77</u>	<u>29.6</u>	<u>312</u>	<u>304</u>	<u>4.40</u>	<u>97.3</u>	<u>3.77</u>	<u>29.6</u>	<u>306</u>	<u>440</u>	<u>3.77</u>	<u>97.3</u>	<u>3.77</u>	<u>29.6</u>	<u>312</u>	<u>305</u>	<u>4.38</u>
363.svwm	<u>87.2</u>	<u>4.02</u>	<u>17.1</u>	<u>302</u>	<u>300</u>	<u>4.42</u>	87.2	4.02	17.1	306	308	4.43	87.3	4.02	17.1	300	299	4.43
370.bt	75.7	2.95	21.2	283	280	3.56	<u>75.7</u>	<u>2.95</u>	<u>21.2</u>	<u>283</u>	<u>280</u>	<u>3.56</u>	75.8	2.94	21.5	291	283	3.52

Results appear in the order in which they were run. Bold underlined text indicates a median measurement.

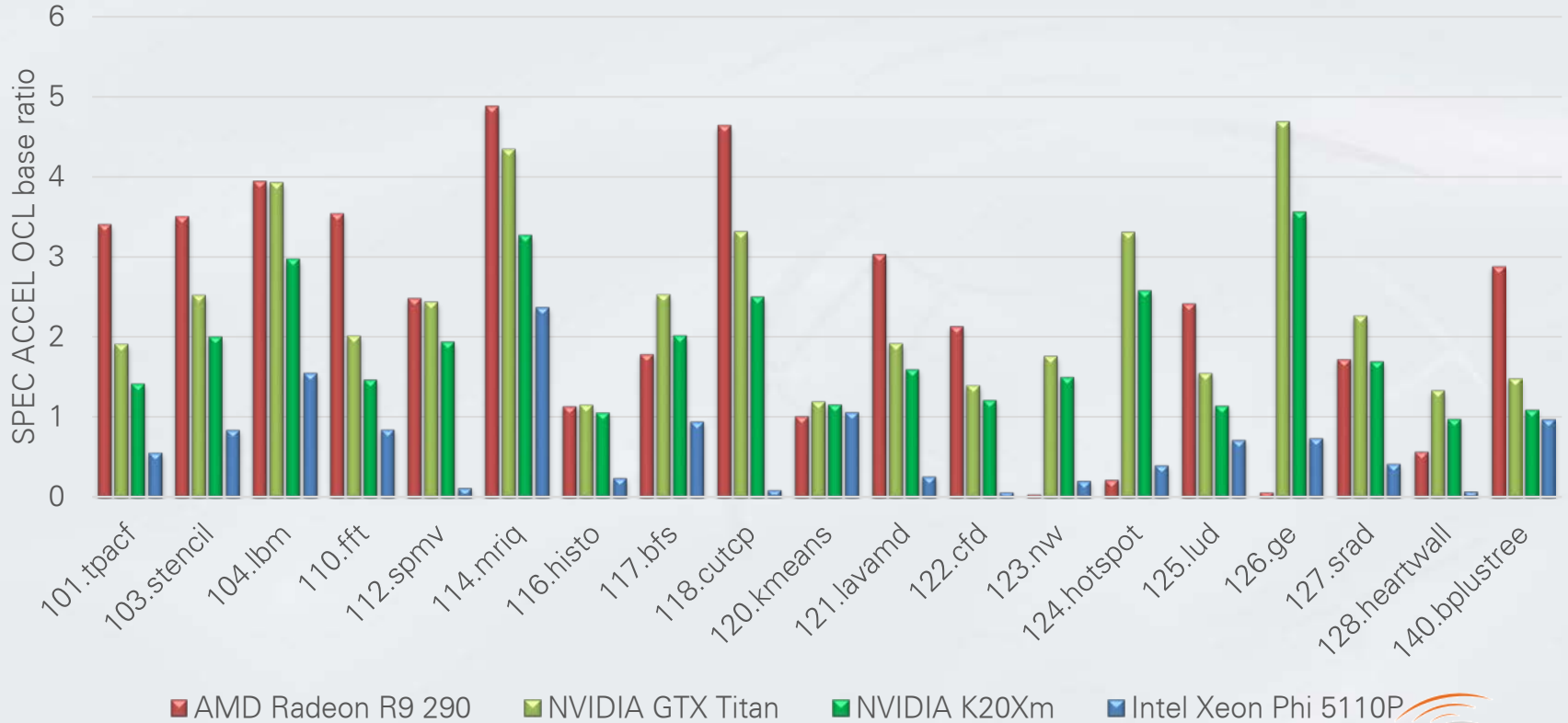
Experiment 1: Impact of ECC (Using result #21 and #22, NVIDIA K40c, base)



Experiment 2: Impact of Clock Boost (result #13, #13, and #14, K40c, base)



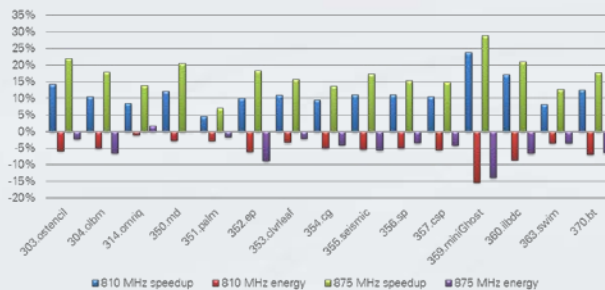
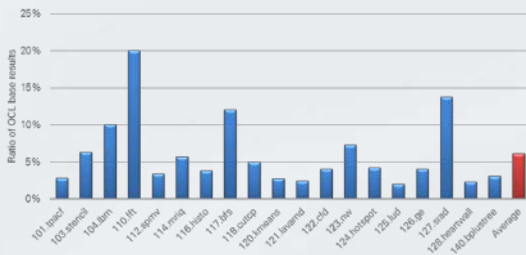
Experiment 3: Apples, Oranges, and other Fruit (using results #28-32, base)



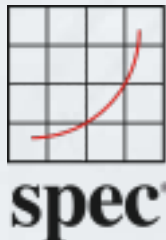
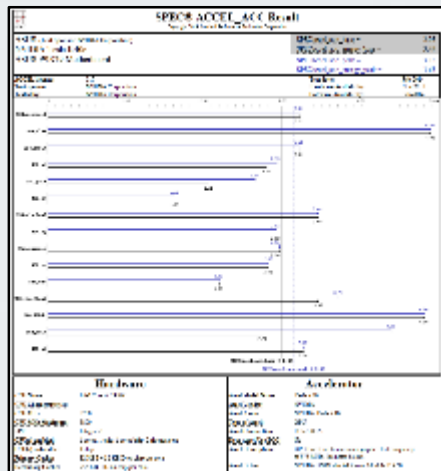
SPEC ACCEL Future Directions

- OpenMP 4.0 target directives
- OpenACC 2.0
- OpenCL 2.0
- Multiple Accelerators

Questions?



Test Name	Speedup	Benchmark Time
303.octencil	~15	~1.5
304.olbm	~10	~1.5
314.omvq	~10	~1.5
350.md	~12	~1.5
351.palm	~8	~1.5
352.ep	~12	~1.5
353.civleaf	~12	~1.5
354.cg	~12	~1.5
355.seismic	~12	~1.5
356.sp	~12	~1.5
357.csp	~12	~1.5
359.min/Ghost	~22	~1.5
360.libdc	~18	~1.5
363.swim	~12	~1.5
370.bt	~12	~1.5



OpenACC Benchmarks	Language	Origin	Application Domain
303.octencil	C	Parboil, University of Illinois	Thermodynamics
304.olbm	C	Parboil, University of Illinois, SPEC CPU2008	Computational Fluid Dynamics, Lattice Boltzmann
314.omvq	C	Rodinia, University of Virginia	Medicine
350.md	Fortran	Indiana University	Molecular Dynamics
351.palm	Fortran	Leibniz University of Hannover	Large-eddy simulation, atmospheric turbulence
352.ep	C	NAS Parallel Benchmarks (NPB)	Embarassingly Parallel
353.civleaf	C, Fortran	Atomic Weapons Establishment (AWE)	Explicit Hydrodynamics
354.cg	C	NPB	Conjugate Gradient Solver
355.seismic	Fortran	GeoDynamics.org, University of Pau	SeismicWave Modeling (PDE)
356.sp	Fortran	NPB	Scalar Penta diagonal solver
357.csp	C	NPB	Scalar Penta diagonal solver
359.min/Ghost	C, Fortran	Sandia National Lab	Finite difference
360.libdc	Fortran	SPEC OMP2012	Fluid Mechanics
363.swim	Fortran	SPEC OMP2012	Weather
370.bt	C	NPB	Block Tridiagonal Solver for 3D PDE

