

PERFORMANCE of VARIOUS COMPUTERS in COMPUTATIONAL CHEMISTRY

15th Daresbury Machine Evaluation Workshop
CCLRC Daresbury Laboratory

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Acknowledgements:

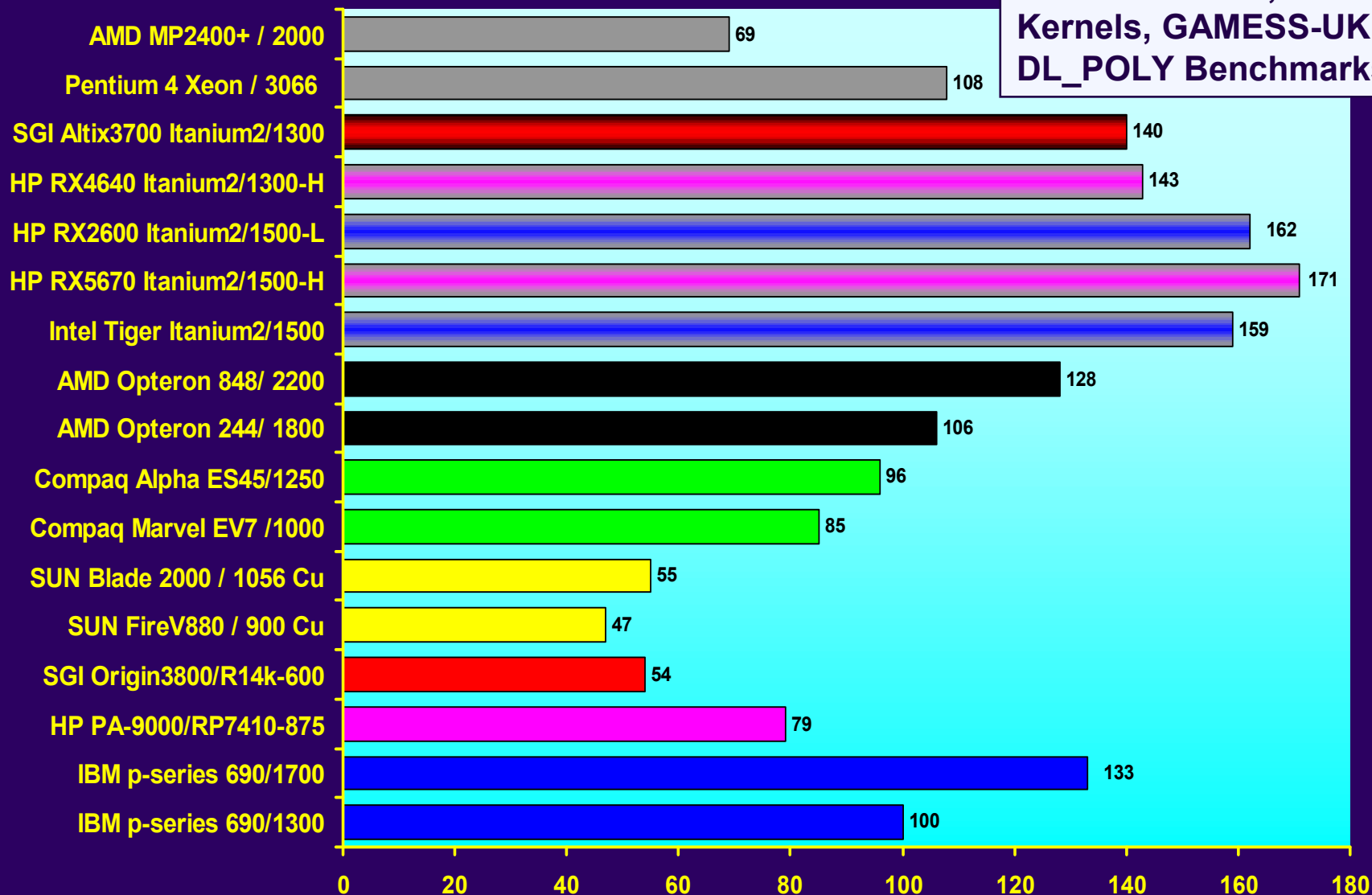
**M. Ehrig (HP/Compaq),
Streamline, Workstations UK, ClusterVision, Compusys**

OUTLINE

- Processor Performance Overview
 - Single-processor performance, Performance Metrics
 - SPEC (Standard Performance Evaluation Corporation)
 - SPEC 95 and **SPEC CPU 2000**
- Computational Chemistry Benchmark (serial) - SPECfp ?
 - Matrix and application “kernels”
 - Application packages (GAMESS-UK, DL_POLY)
 - Comparison involves 220+ computers (vector supercomputers, workstations, PCs and MPP nodes)
- Recently extended to include “RATE” benchmarks
 - URLs: Powerpoint presentation and Paper:
<http://www.cse.clrc.ac.uk/disco/hw-perf.shtml>
- *Benchmarking of Parallel Commodity Systems*

MEW14 (2003) - Summary PI relative to the IBM p-series 690/pwr4 1.3 GHz

The MATRIX-97, Chemistry Kernels, GAMESS-UK and DL_POLY Benchmarks



MACHINES UNDER EVALUATION

<u>Machine</u>	<u>Processor</u>
<u>AMD Opteron</u>	<u>850 (2.4 GHz), 248 (2.2 GHz), 848 (2.2 GHz), 246 (2.0 GHz), 244 (1.8 GHz), 842 (1.6 GHz)</u>
<u>Intel IA32</u>	<u>P4 Xeon 3.06 GHz, 3.2 GHz</u>
<u>Intel x86-64 (EM64T)</u>	<u>Nocona 3.2 GHz, 3.4 GHz, 3.6GHz</u>
SUN Blade 2000 / 1056 Cu	UltraSPARC-3 / 1056 MHz
SUN Fire V880 / 900 Cu	UltraSPARC-3 / 900 MHz
<u>HP 9000 / RP3440-4</u>	<u>PA8800 / 1000MHz</u>
<u>HP 9000 / RP7410</u>	<u>PA8700+ / 875MHz</u>
<u>HP RX4640 (4-way)</u>	<u>Itanium 2 / 1300 MHz (3 MB L3)</u>
<u>HP RX2600 (2-way)</u>	<u>Itanium 2 / 1500 MHz (6 MB L3)</u>
<u>HP RX5670 (4-way)</u>	<u>Itanium 2 / 1500 MHz (6 MB L3)</u>
<u>HP RX1620 (2-way)</u>	<u>Itanium 2 / 1600 MHz (3 MB L3)</u>
<u>Intel Tiger (4-way)</u>	<u>Itanium 2 / 1000 MHz (3 MB L3)</u>
<u>Intel Tiger (4-way)</u>	<u>Itanium 2 / 1500 MHz (6 MB L3)</u>

<u>Machine</u>	<u>Processor</u>
HP/Compaq ES45	AXP A21264C / 1000 MHz
HP/Compaq ES45	AXP A21264C / 1250 MHz
Compaq Marvel	EV7 1000 MHz
<u>SGI Altix 3700</u>	<u>Itanium 2 / 1.5 & 1.3 GHz</u>
SGI Origin3800/R14k	R14000/R14010 600 MHz
SGI Origin300/R14k	R14000/R14010 500 MHz
SGI O2/R12k-SC	R12000/R12010 270 MHz
IBM p-Series 630	RS/6000 /POWER4 1.0GHz
IBM p-Series 690	RS/6000 /POWER4 1.3GHz
IBM p-Series 690	RS/6000 /POWER4 1.7GHz
<u>IBM p5 570/1.9</u>	<u>RS/6000 /POWER5 1.9GHz</u>
<u>Vector Supercomputers</u>	
<u>NEC SX-6i, SX-5, SX-4</u> Cray Y-MP/J90-10, FUJITSU VPP/300, Cray YMP C98/4256	
<u>MPP Nodes</u>	
Cray T3E/1200	AXP EV56 600 MHz
IBM SP / Power3	RS/6000 WH2 - 375 MHz

SPEC Benchmarks

- Compute intensive categories
 - integer versus floating point
 - conservative versus aggressive compilation
 - speed versus throughput
- Composite Metrics - SPEC CPU 2000

NOT:

- Graphics
- Network
- I/O

<http://www.specbench.org>

	SPEED	THROUGHPUT
Aggressive	SPECint2000 SPECfp2000	SPECint_rate2000 SPECfp_rate2000
Conservative	SPECint_base2000 SPECfp_base2000	SPECint_rate_base2000 SPECfp_rate_base2000

- SPECratio - $T(\text{measured system}) / T(\text{reference})$
- Reference = 300 MHz Ultra 5/10 (100)
- SPECfp2000 - geometric mean of 14 ratios, one for each benchmark
- SPECint2000 - geometric mean of 12 ratios, one for each benchmark

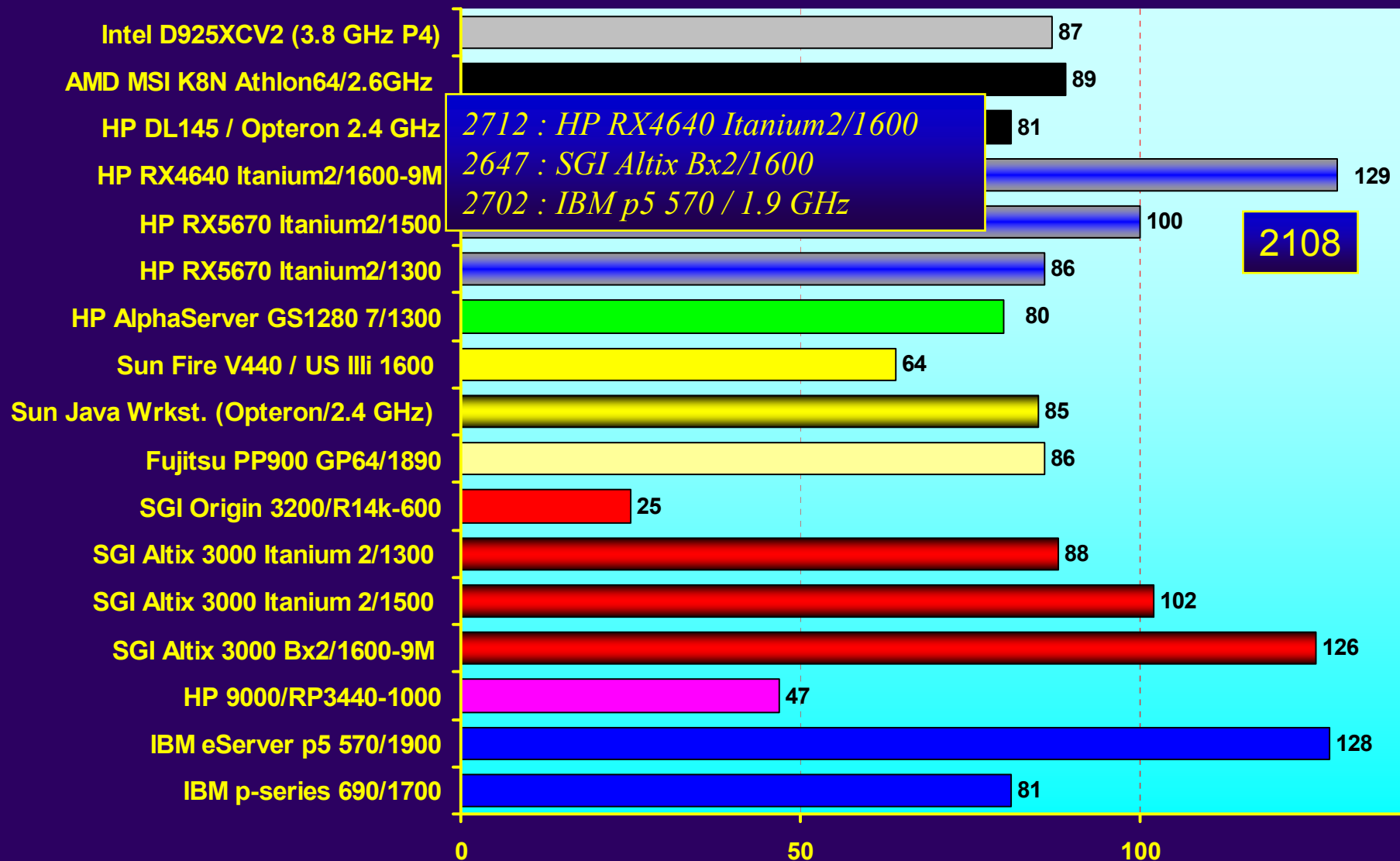
SPEC CPU 2000 - Floating point Benchmark Suite (SPECfp2000)

Benchmark	Language	Description
168.wupwise	F77	Physics: Quantum chromodynamics
171.swim	F77	Shallow water modelling
172.mgrid	F77	Multigrid solver: 3D potential field
173.applu	F77	Partial differential equations
177.mesa	C	3D graphics library
178.galgel	F90	Computational fluid dynamics
179.art	C	Image recognition / neural networks
183.quake	C	Seismic wave propagation simulation
187.facerec	F90	Image processing: Face recognition
188.amp	C	Computational chemistry
189.lucas	F90	Number theory / primality testing
191.fma3d	F90	Finite-element crash simulation
200.sixtrack	F77	Nuclear physics accelerator design
301.apsi	F77	Metereology: Pollutant distribution

Reference: 300 MHz Ultra 5/10 = 100

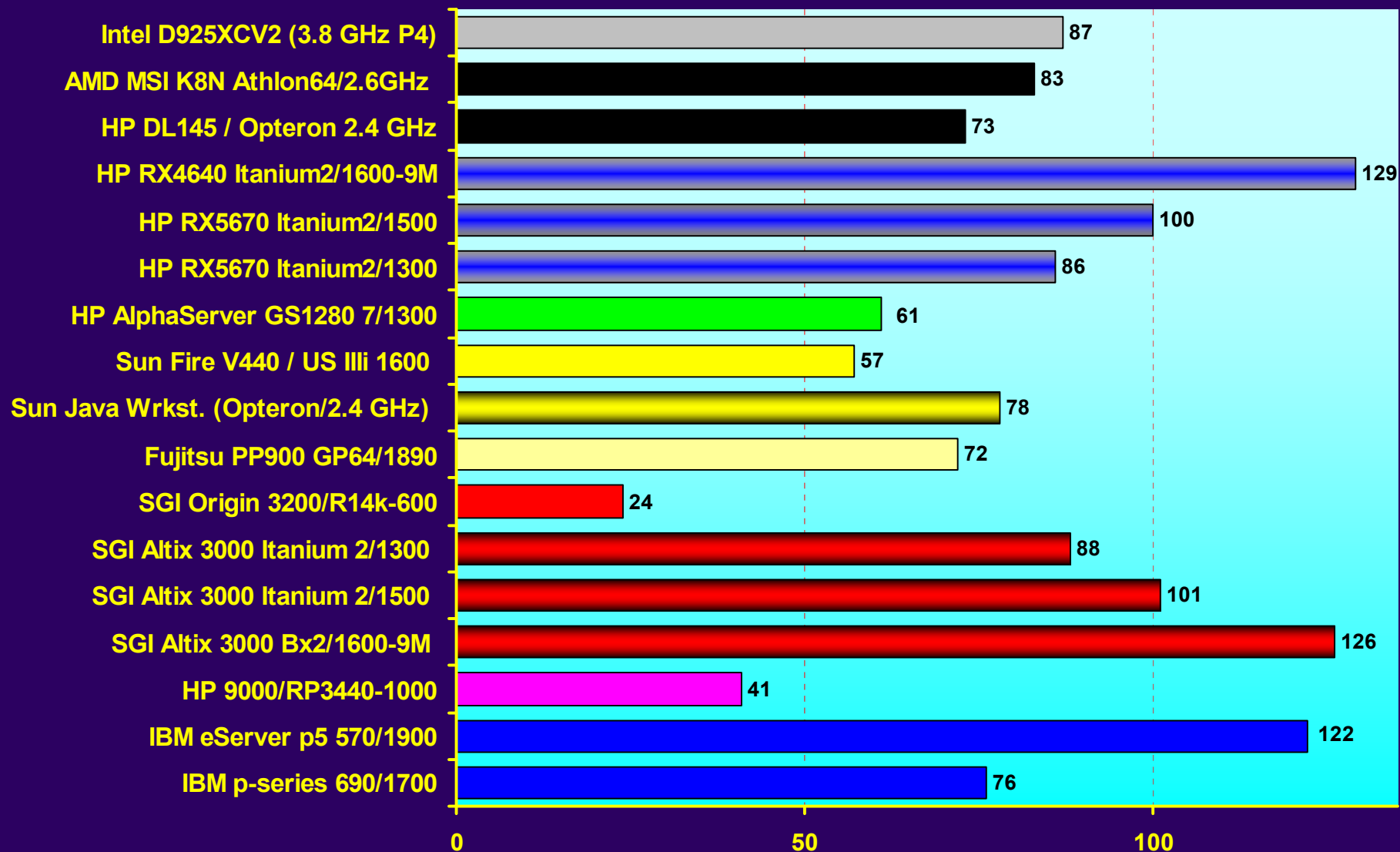
SPEC CPU 2000 - SPECfp2000

Values relative to HP RX5670 Itanium2/1.5GHz



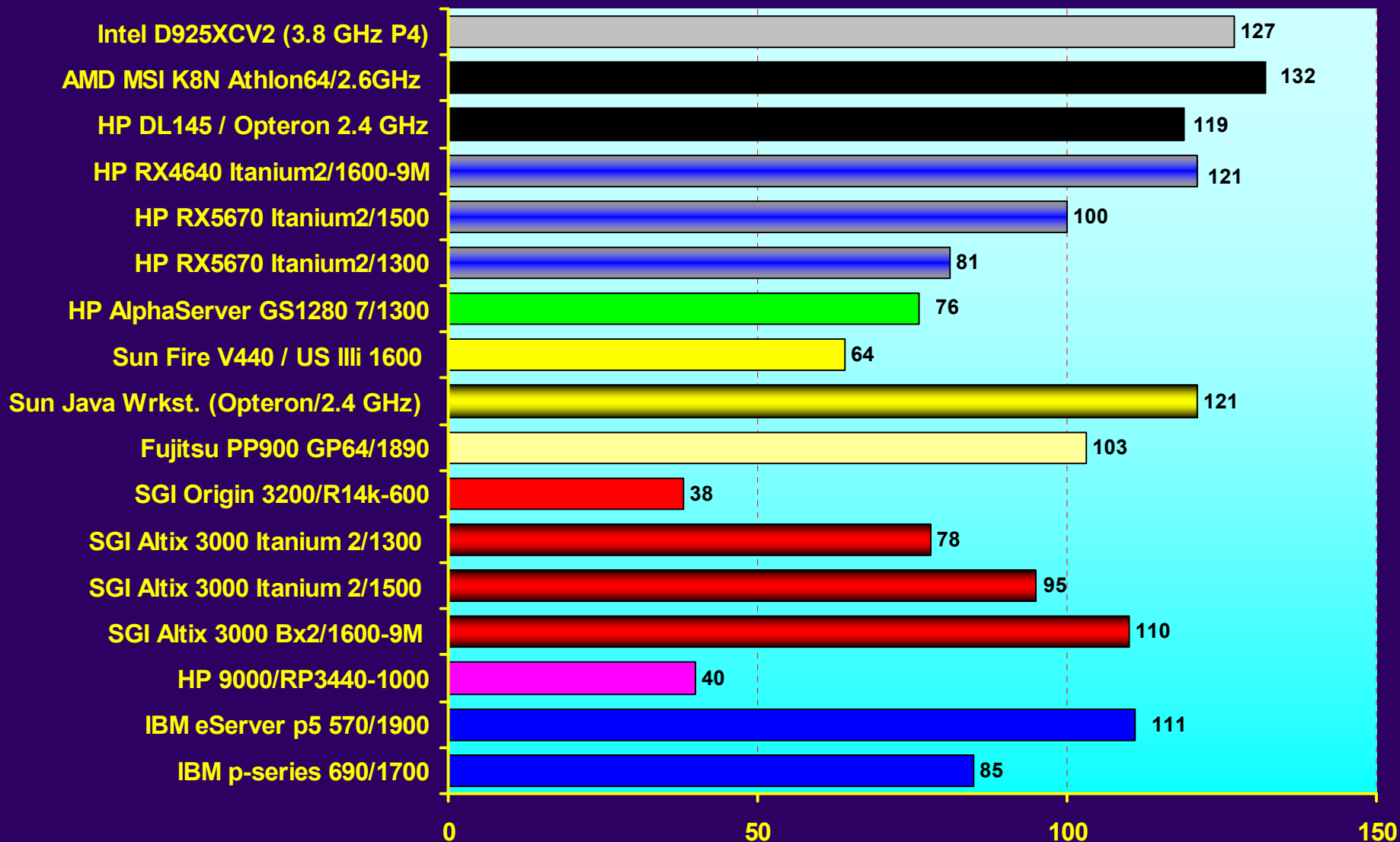
SPEC CPU 2000 - SPECfp2000_base

Values relative to HP RX5670 Itanium2/1.5GHz



SPEC CPU 2000 - SPECint2000

Values relative to HP RX5670 Itanium2/1.5GHz

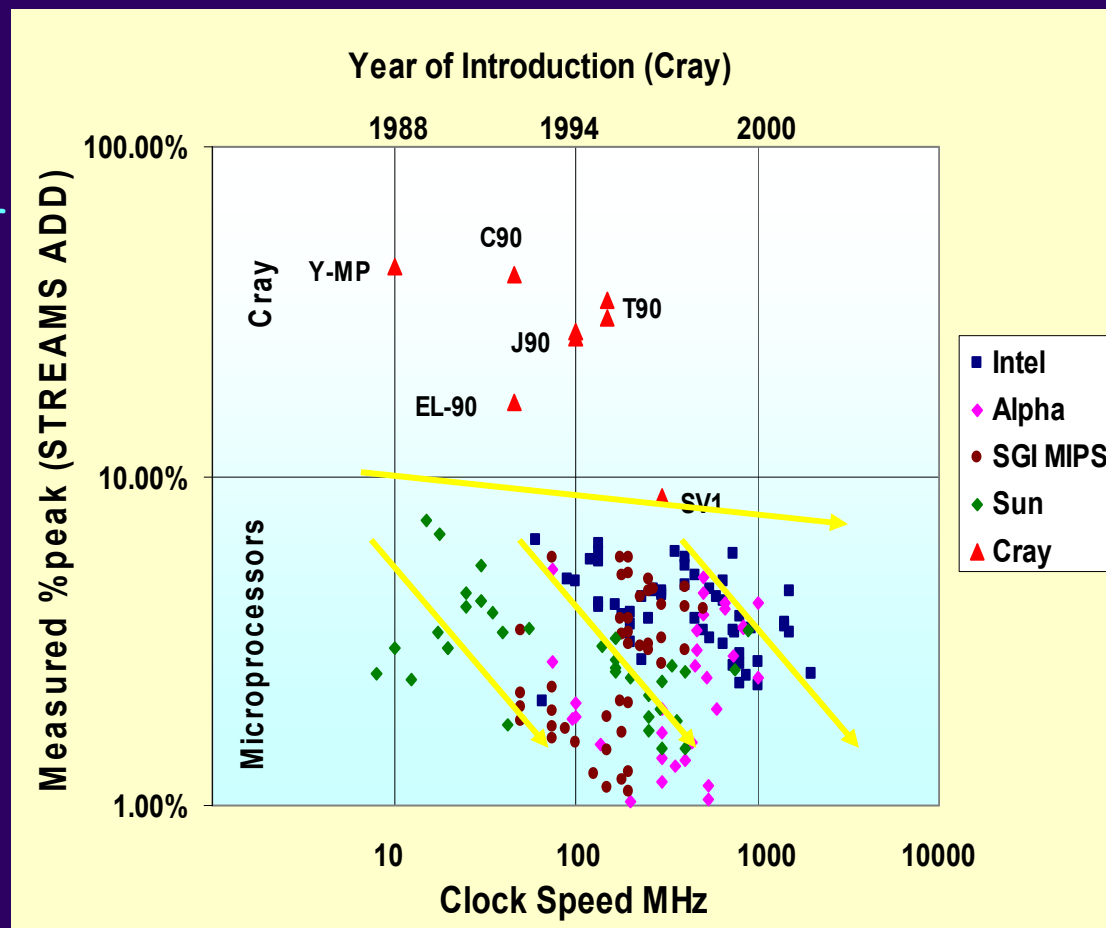


Memory System Performance Limitations

Why applications with limited memory reuse perform inefficiently today

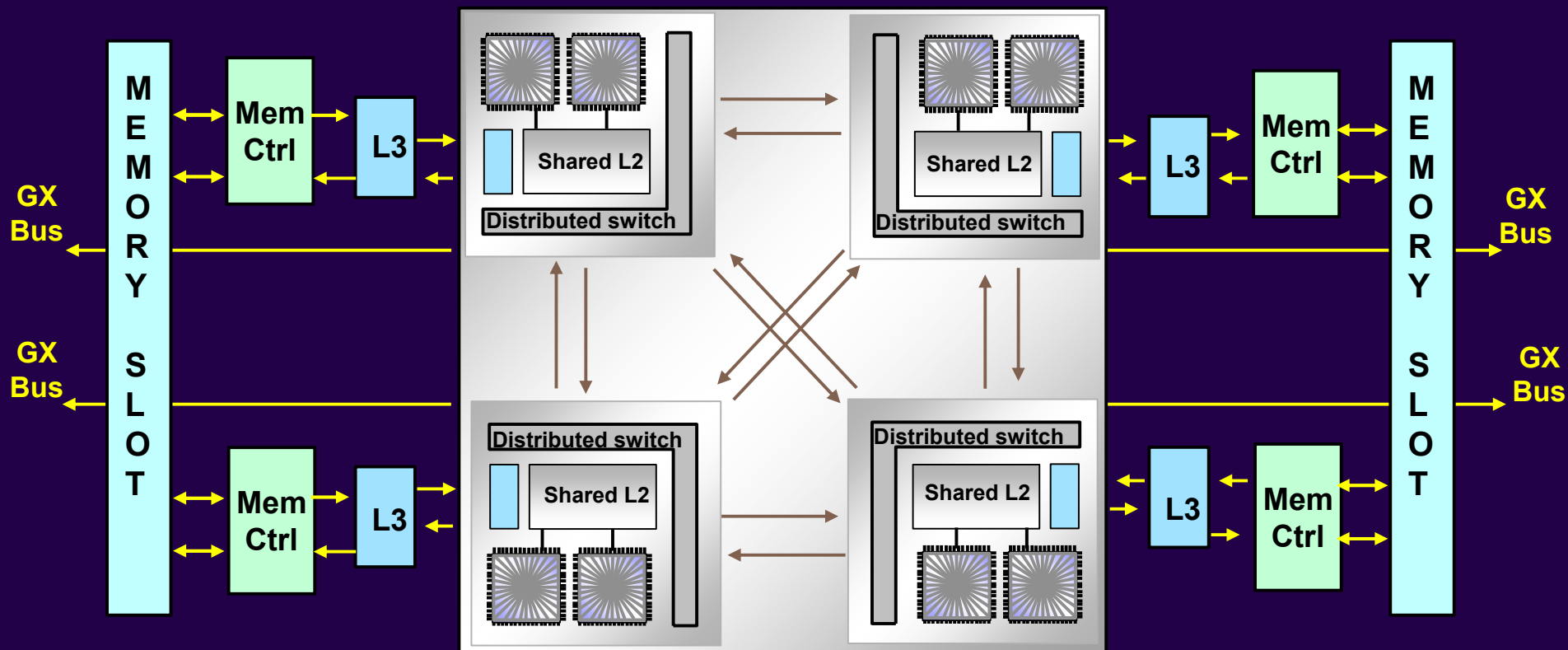
- STREAMS ADD: Computes $A + B$ for long vectors A and B (historical data available)
- New microprocessor generations "reset" performance to at most 6% of peak
- Performance degrades to 1% - 3% of peak as clock speed increases within a generation

Goal: understand application performance to memory reuse and other factors



IBM p-series 690Turbo: Multi-chip Module (MCM)

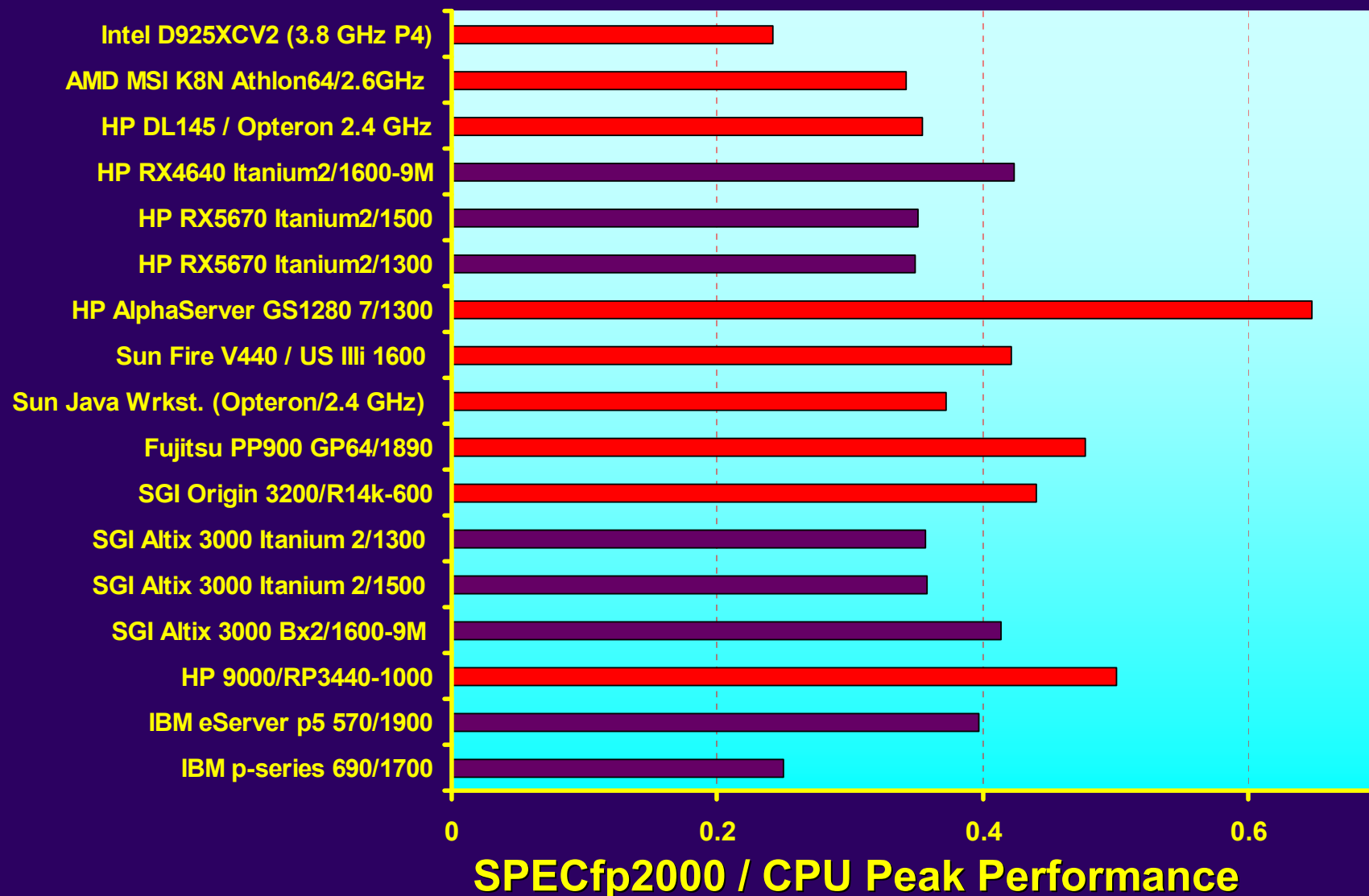
Four POWER4 chips (8 processors) on an MCM, with two associated memory slots



L3 cache shared 4 GX Bus links for external connections across all processors

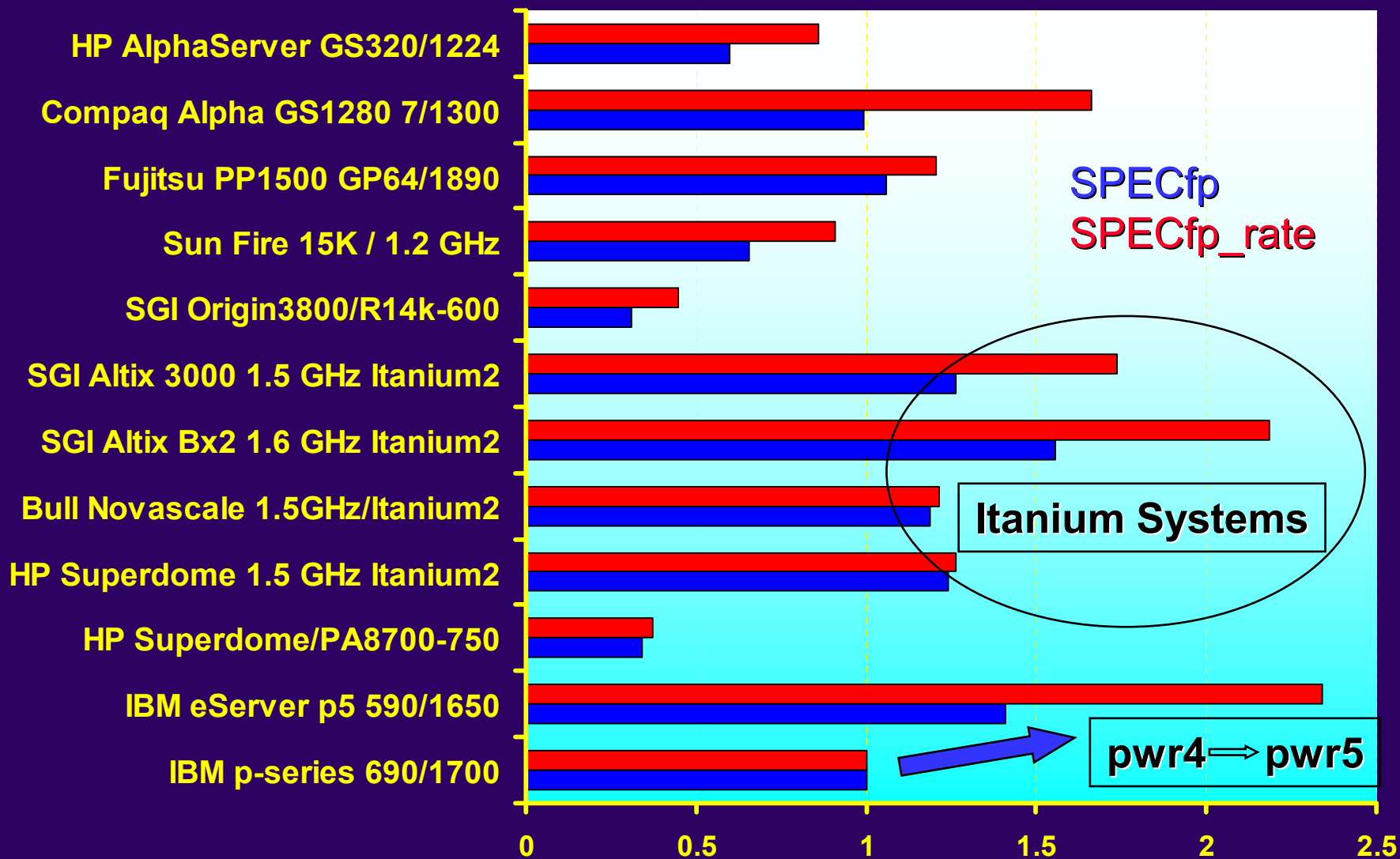
SPEC CPU 2000 - SPECfp2000

Units of SPECfp as a function of Peak Performance



SPEC CPU 2000 - SPECfp vs SPECfp_rate (32 CPUs)

Values relative to IBM 690 Turbo 1.7 GHz

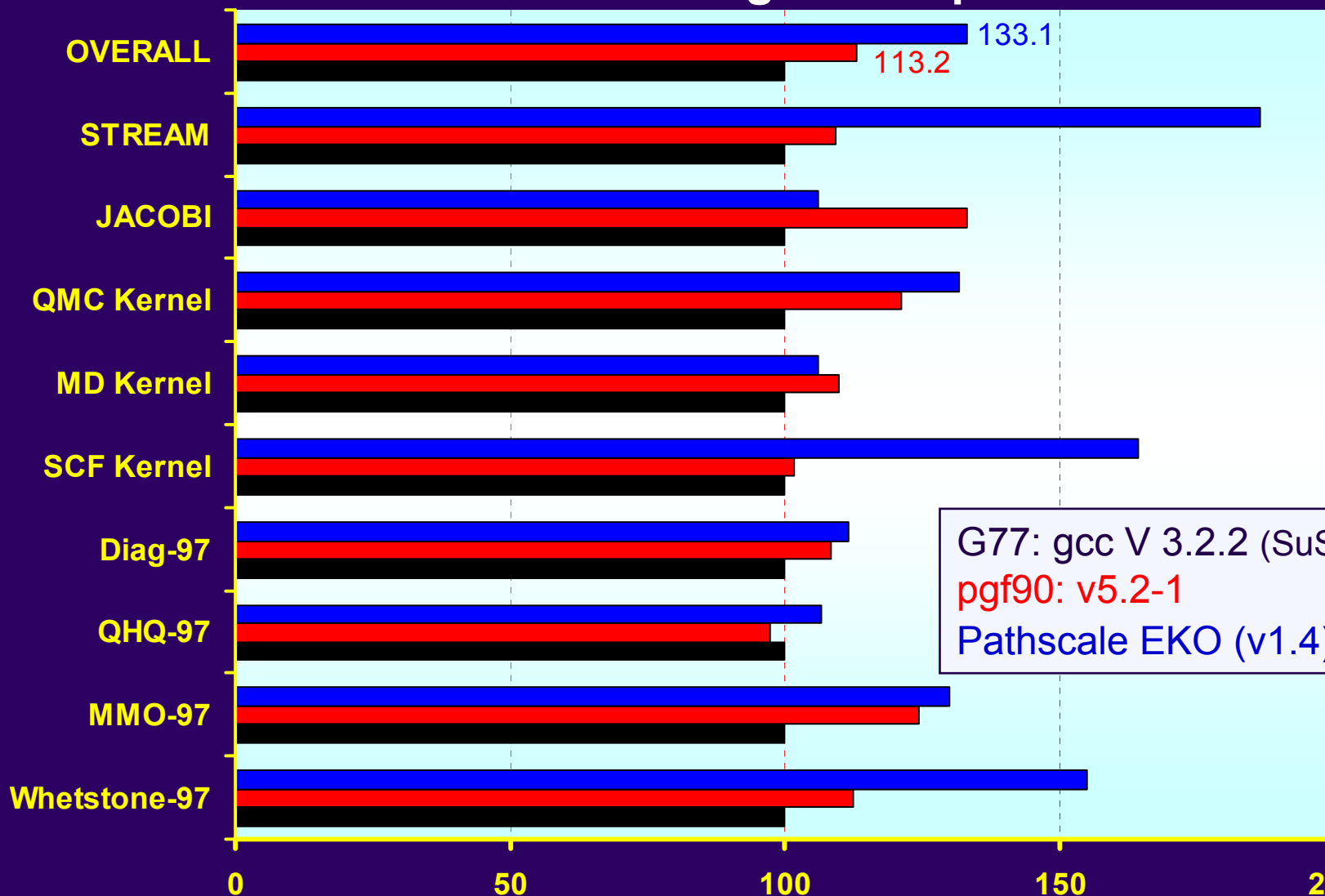


Computational Chemistry Benchmark Suite

- Benchmark suite developed to incorporate:
 - Matrix “kernels” (MATRIX-89 and MATRIX-97)
 - Application “kernels”
 - Application packages (e.g. GAMESS-UK, DL_POLY)
- Implemented on Supercomputers, servers, workstations, PCs and parallel machines
 - Matrix Operations / Matrix multiplication and matrix diagonalisation
 - Computational Chemistry Kernels - four typical application kernels (direct-SCF, MD, QMC and Jacobi eigen solver)
 - STREAM (memory bandwidth)
 - Quantum Chemistry Calculations - twelve typical applications, including SCF, direct-SCF, CASSCF, MCSCF, direct-CI and MRD-CI, MP2, 2nd derivatives (GAMESS-UK-89 and GAMESS-UK-99)
 - Molecular Dynamics Calculations - six typical simulations

Fortran Compilers - Performance

Performance relative to GNU g77 on Opteron 246 / 2.0 GHz



G77: gcc V 3.2.2 (SuSE Linux)
 pgf90: v5.2-1
 Pathscale EKO (v1.4)

COMPUTATIONAL CHEMISTRY BENCHMARKS I. Matrix Operations

MATRIX OPERATIONS (MATRIX-89 and MATRIX-97)

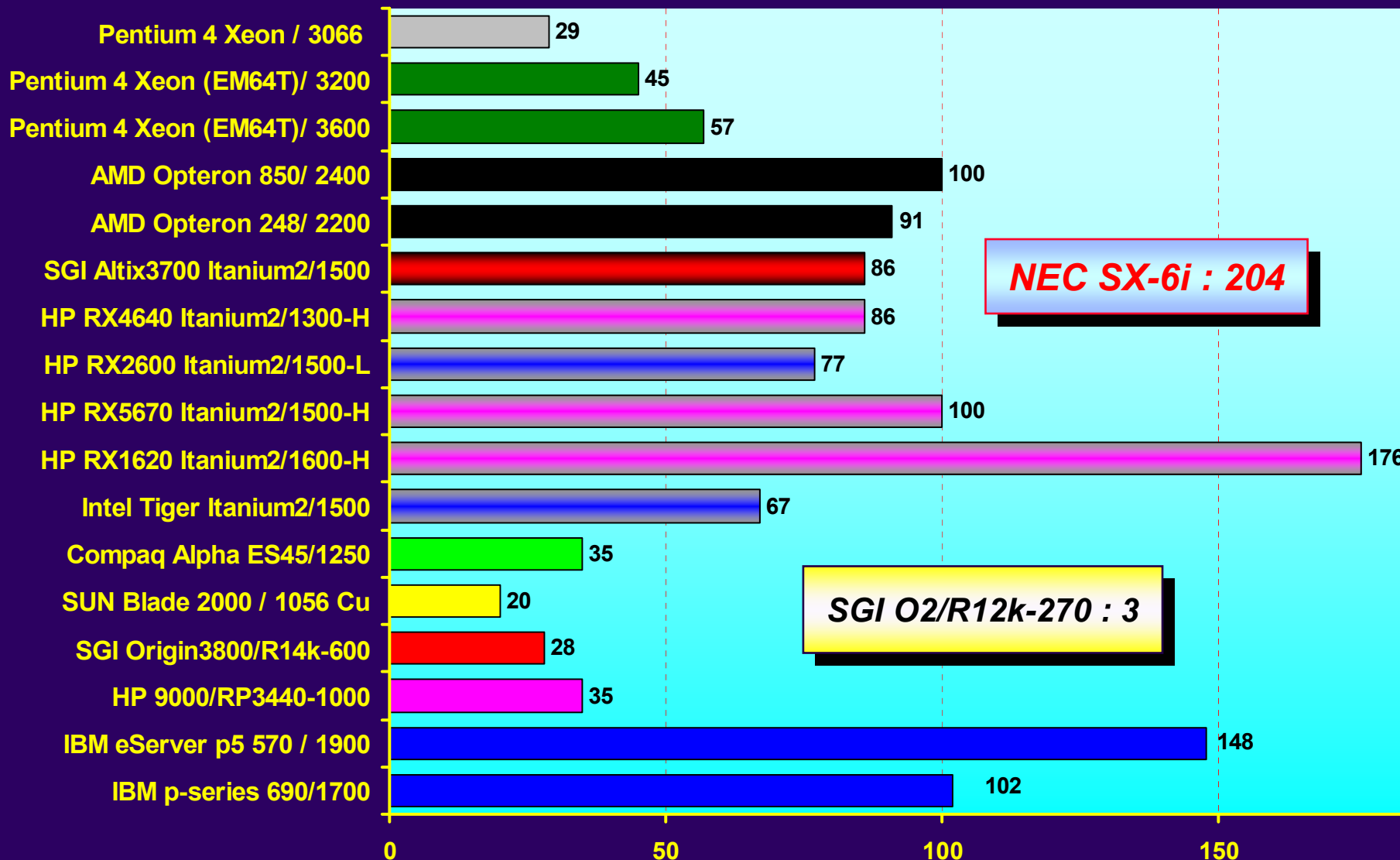
- SPARSE Matrix Multiply BenchMark
 - MMO operation is central to the efficient operation of modern QC codes. In this benchmark a series of MMOs ($R = A \times B$) are performed involving matrices of increasing order:
 - MATRIX-89: 10, 20, 30, ... , 100 (B is sparse)
 - **MATRIX-97: 50, 100, 150, ... , 500 (B is sparse)**
- Diagonalisation Benchmark
 - Based on diagonalising a series of real symmetric matrices. Measures the performance of 8 routines from mathematical libraries and QC codes:
 - MATRIX-89: 10, 20, 30, ... , 100
 - **MATRIX-97: 50, 100, 150, 200, 250, 300**
- Q[†]HQ Benchmark
 - Designed to extend MMO benchmark by allowing for the use of library routines e.g. BLAS. Uses both a scalar and vector algorithm:
 - MATRIX-89: 10, 20, 30, ... , 150
 - **MATRIX-97: 20, 40, 60, ... , 300**

Memory bandwidth

-lblas

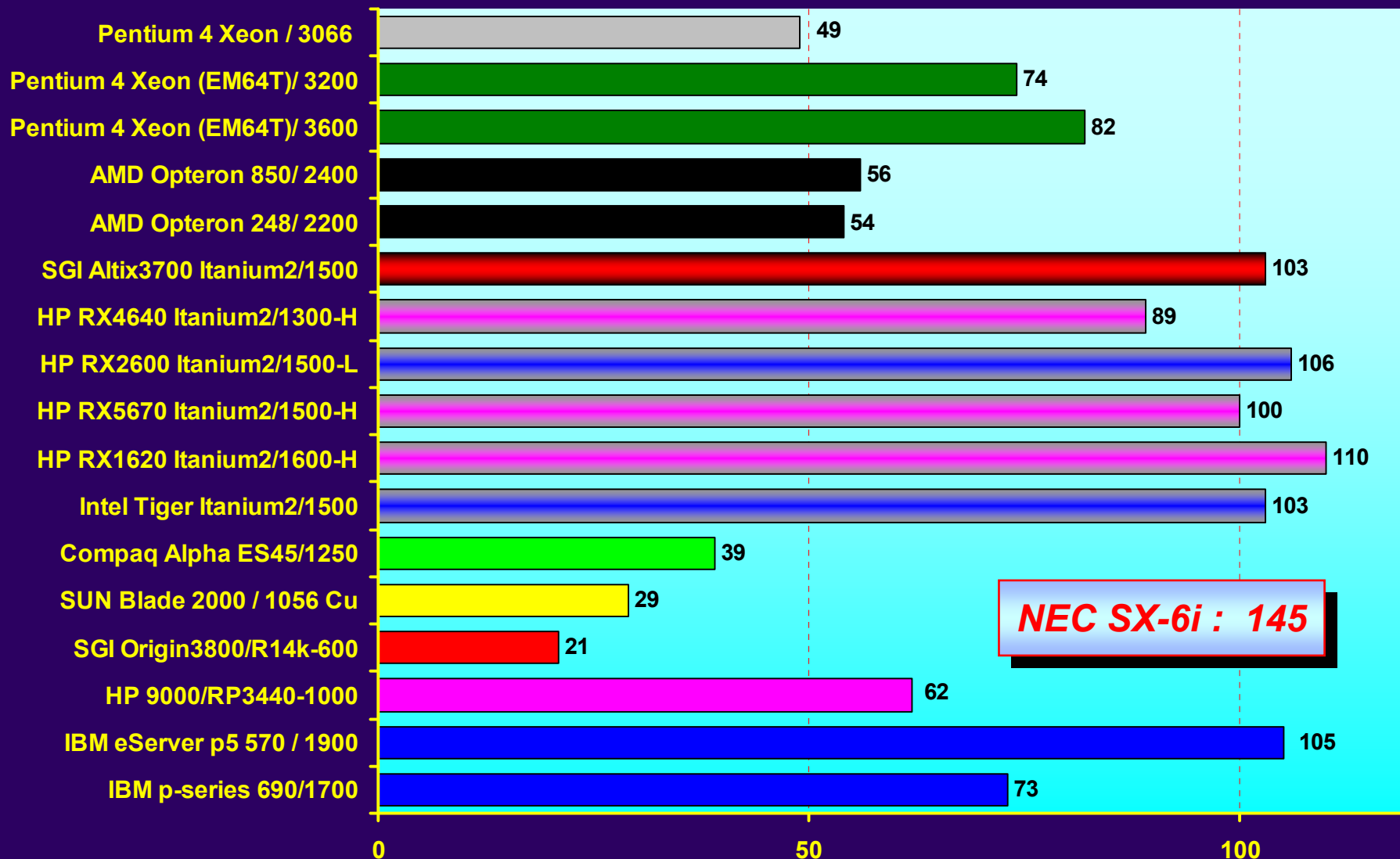
Matrix-97: SPARSE MMO Benchmark.

Performance relative to the HP RX5670 Itanium2/1.5GHz



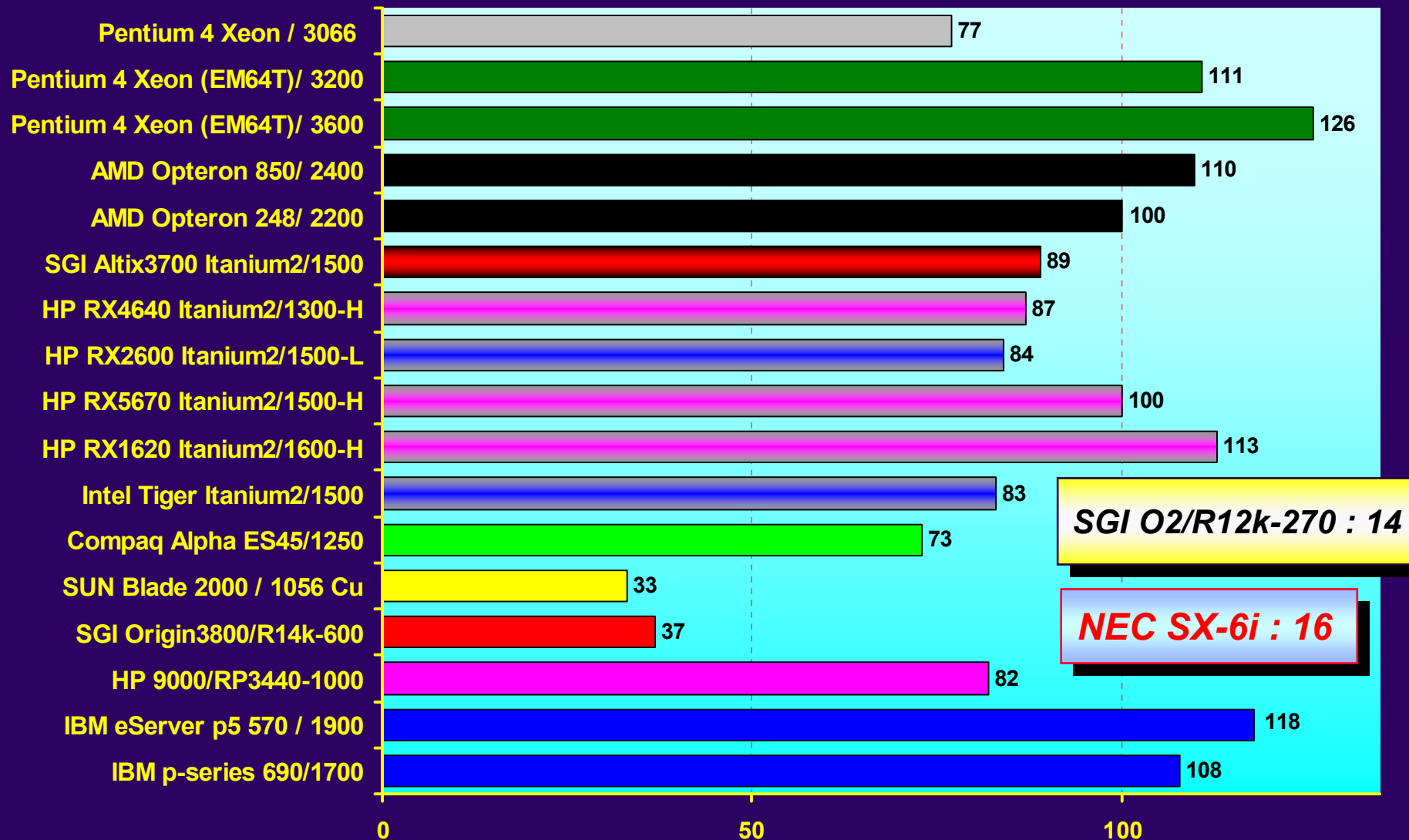
Matrix-97: Q[†]HQ MMO Benchmark.

Performance relative to the HP RX5670 Itanium2/1.5GHz



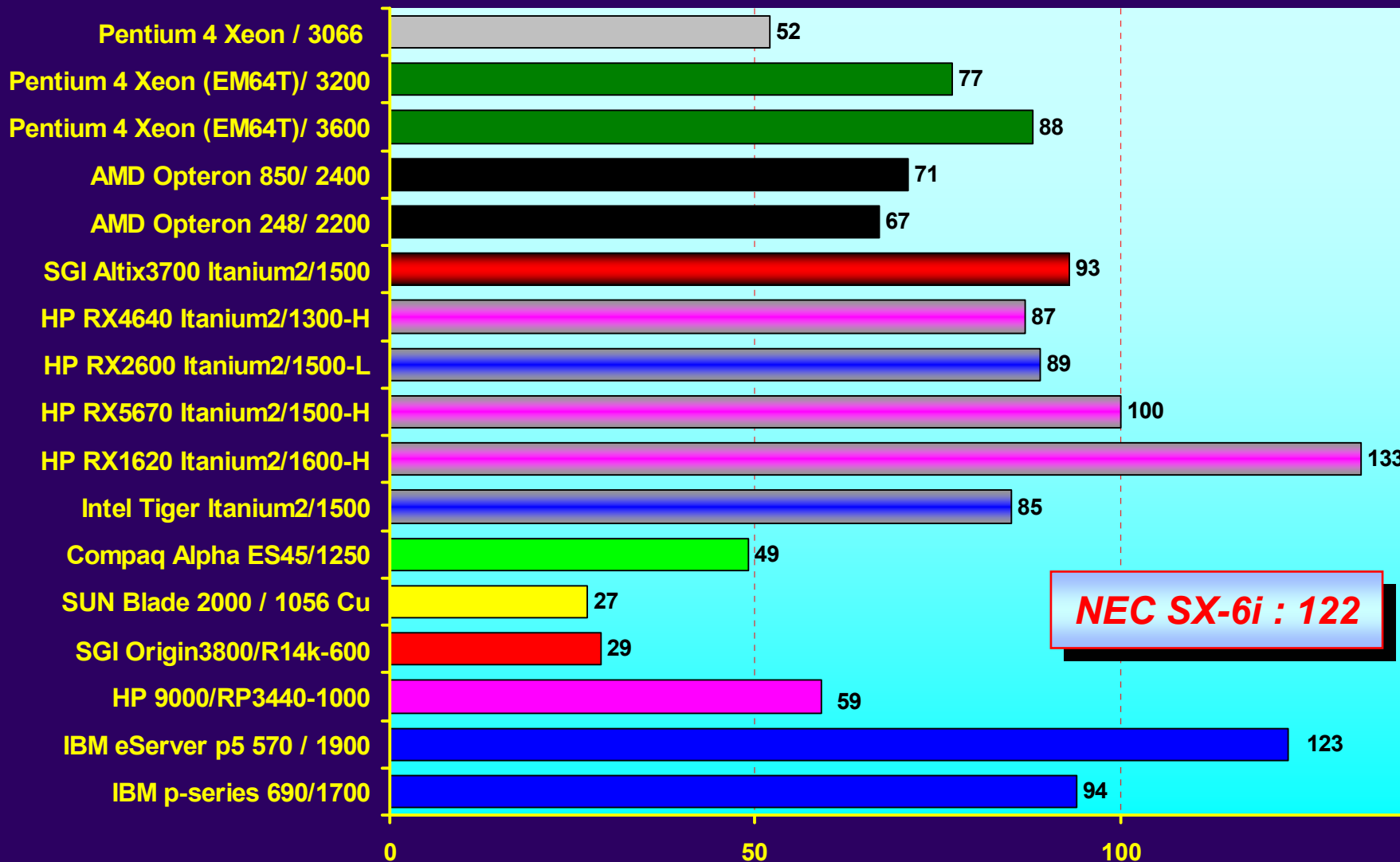
Matrix-97: Diagonalisation Benchmark

Performance relative to the HP RX5670 Itanium2/1.5GHz



The Matrix-97 Benchmarks.

Performance relative to the HP RX5670 Itanium2/1.5GHz



COMPUTATIONAL CHEMISTRY KERNELS

Programs that are realistic models of actual chemical applications or algorithms

■ Self consistent Field (SCF)

- SCF code using distributed primitive 1s gaussian functions as a basis (thus emulating the use of s, p, functions); performs direct-SCF calculation on Be_4 (60 functions).

■ Molecular Dynamics (MD)

- This code bounces a few thousand argon atoms around in a box with periodic boundary conditions. LJ pair-wise interactions are used with integration of the Newtonian equations of motion.

■ Quantum Monte Carlo (QMC)

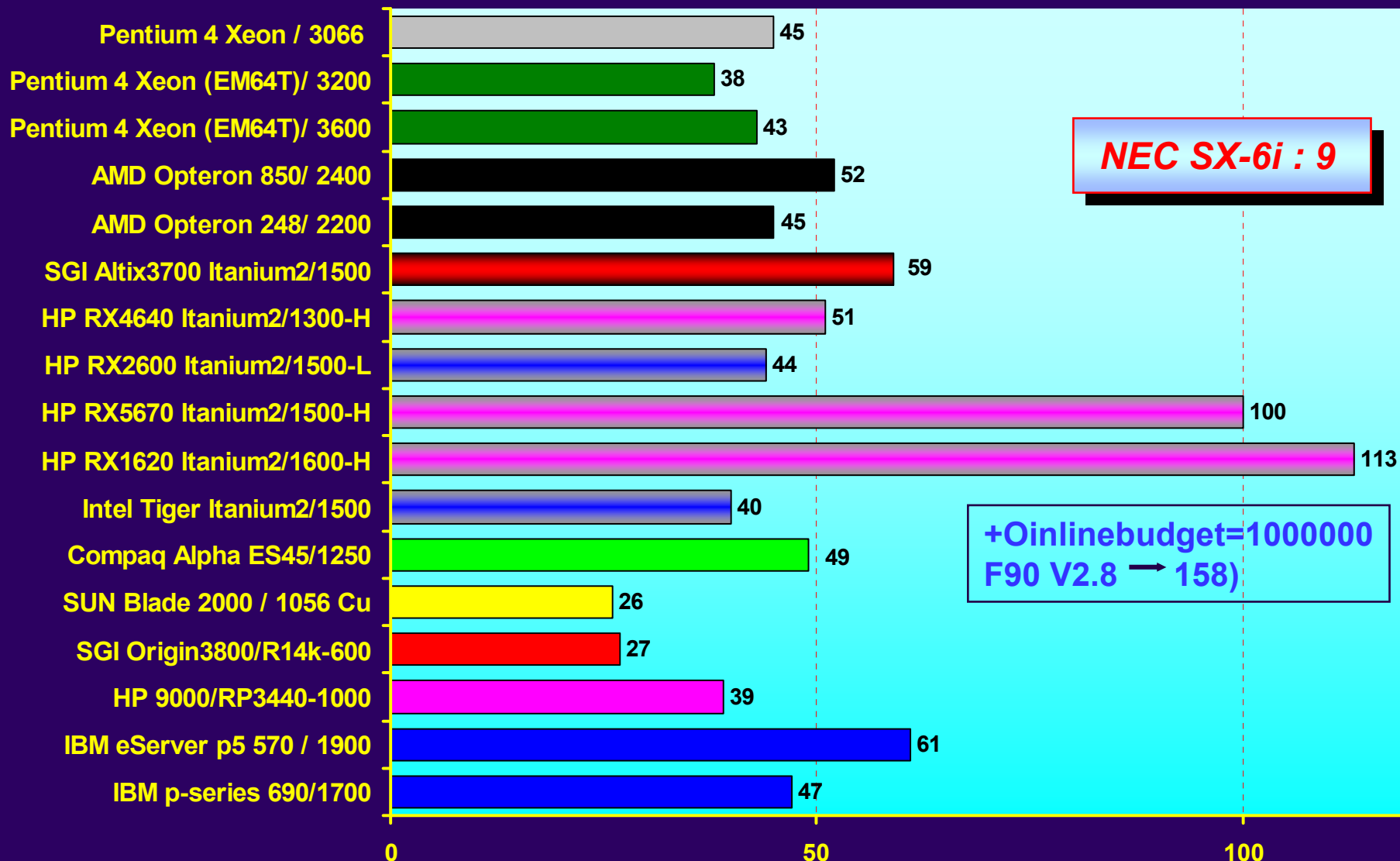
- This code evaluates the energy of the simplest explicitly correlated electronic wavefunction for the He atom using a variational monte-carlo method without importance sampling.

■ Jacobi iterative linear equation solver (JACOBI)

- JACOBI uses a naive jacobi iterative algorithm to solve a linear equation. All the time is spent in a large matrix-vector multiplication.

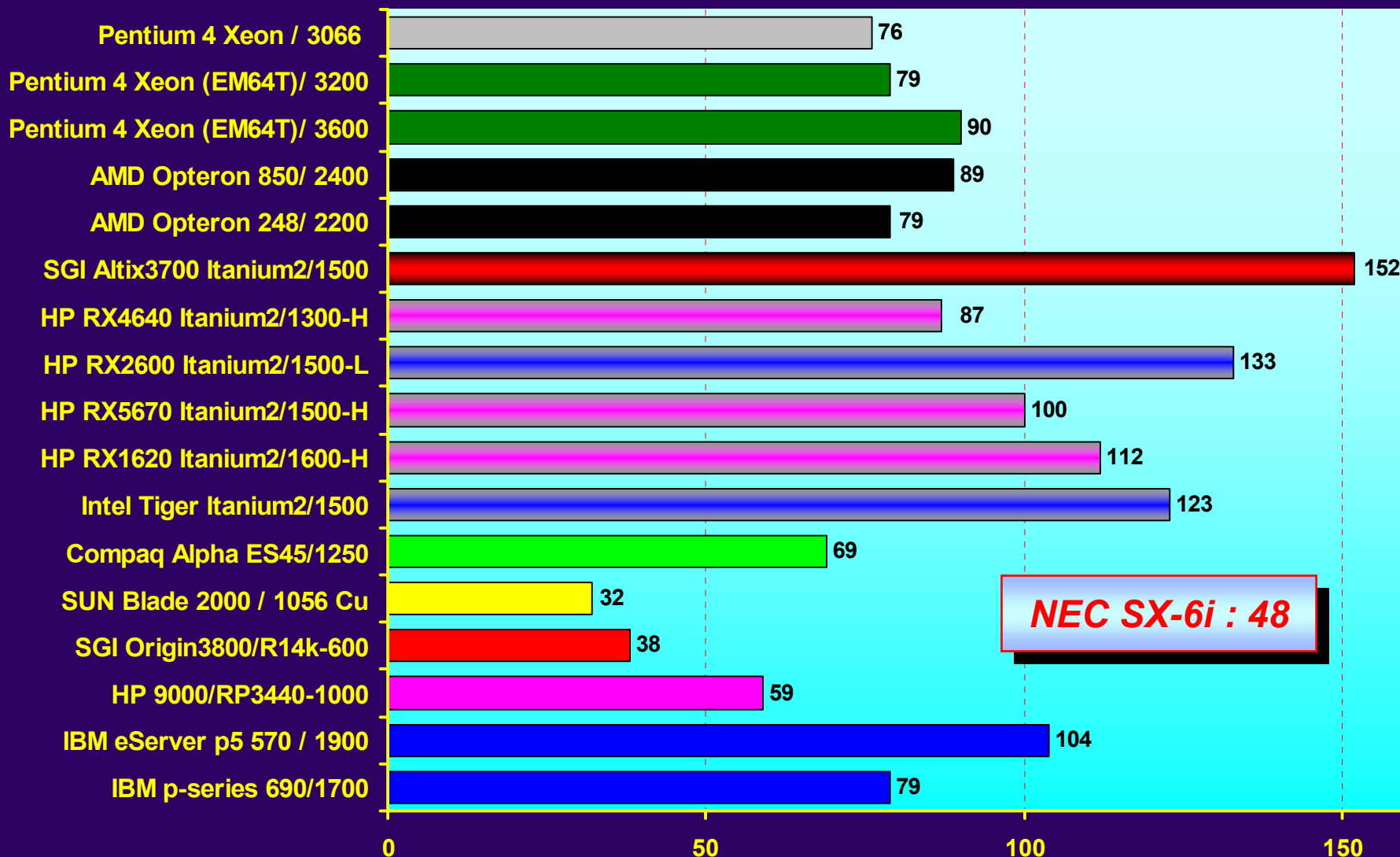
Computational Chemistry Kernels - Direct-SCF.

Performance relative to the HP RX5670 Itanium2/1.5GHz



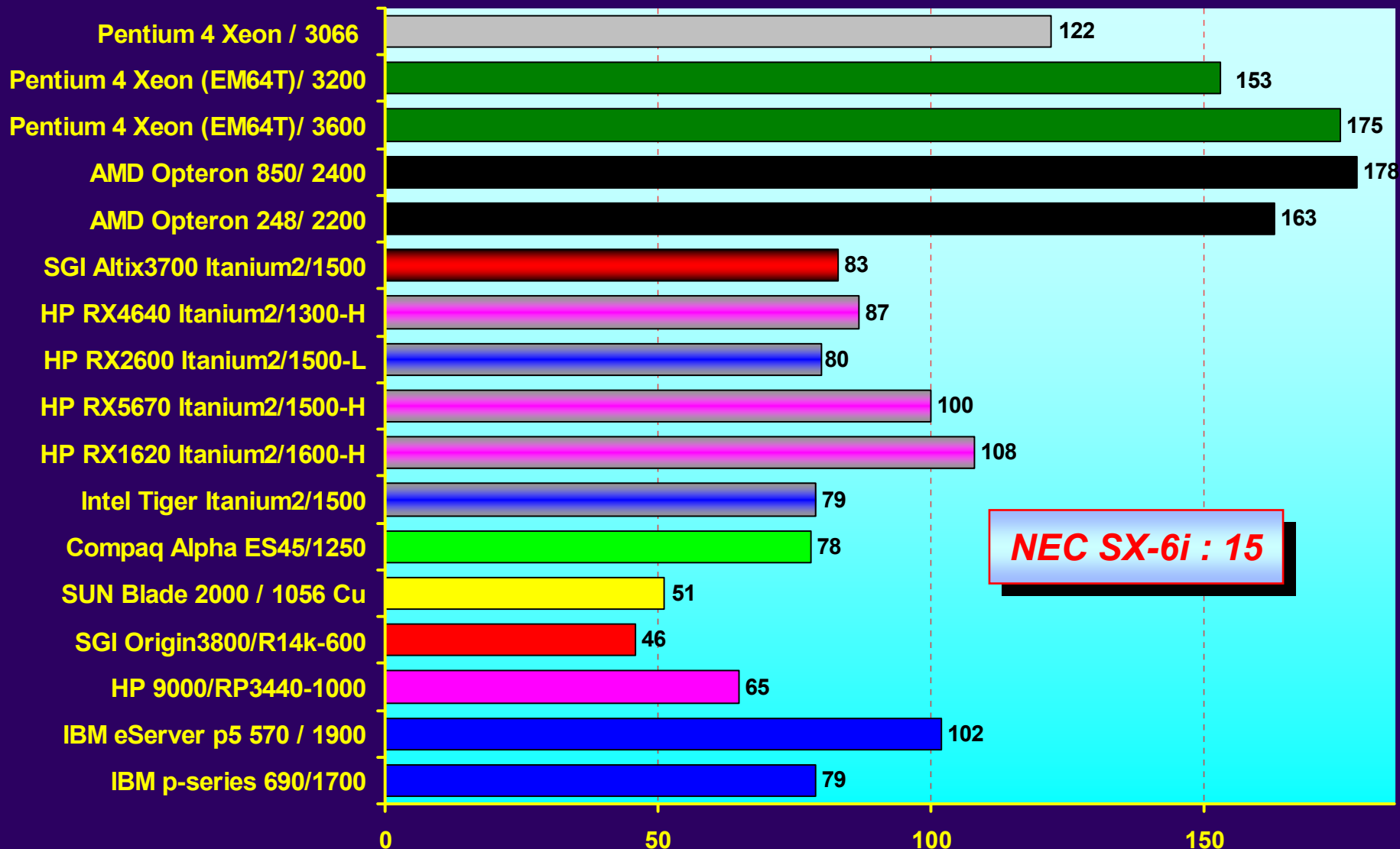
Chemistry Kernels - Molecular Dynamics.

Performance relative to the HP RX5670 Itanium2/1.5GHz



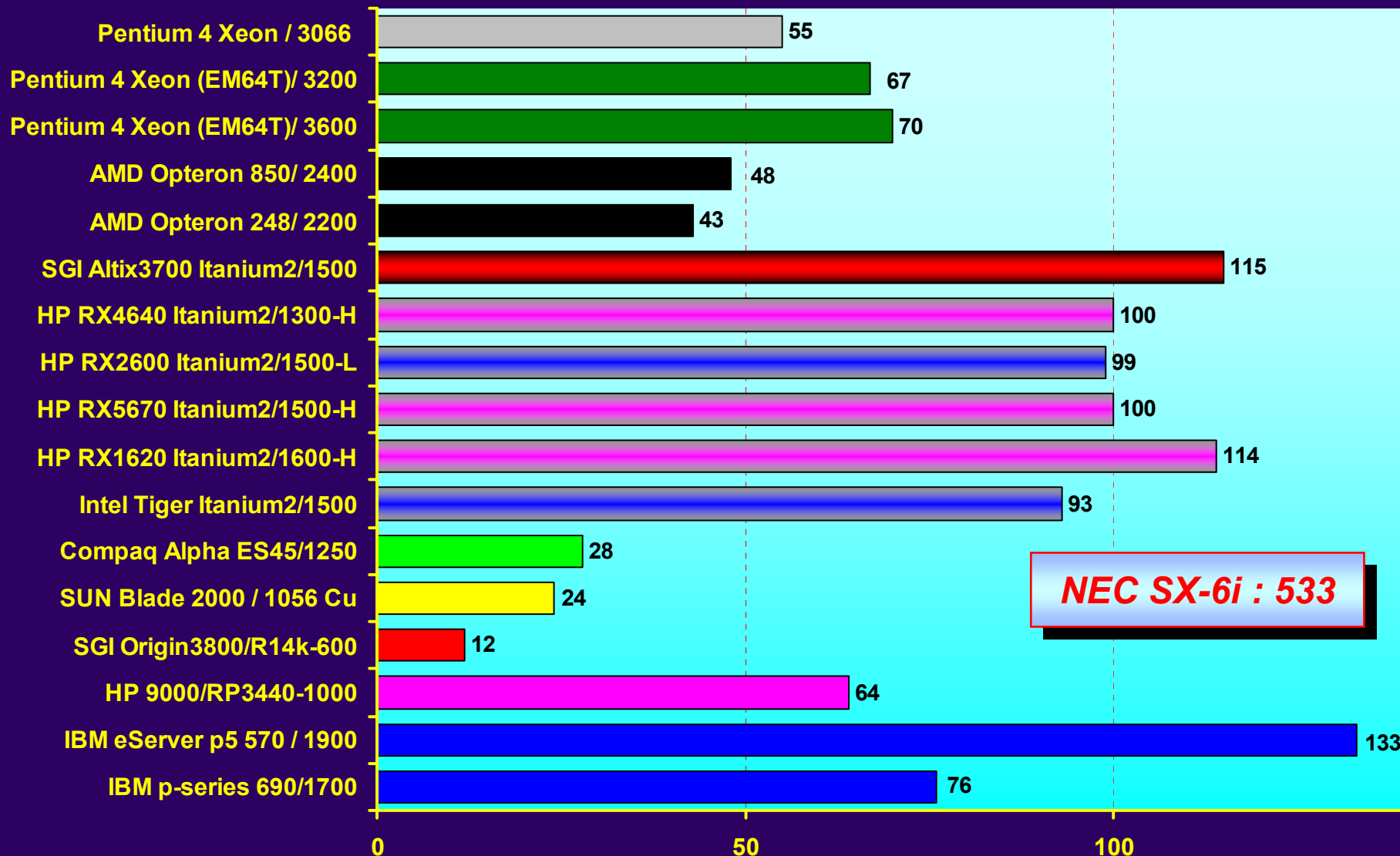
Chemistry Kernels - Quantum Monte Carlo.

Performance relative to the HP RX5670 Itanium2/1.5GHz



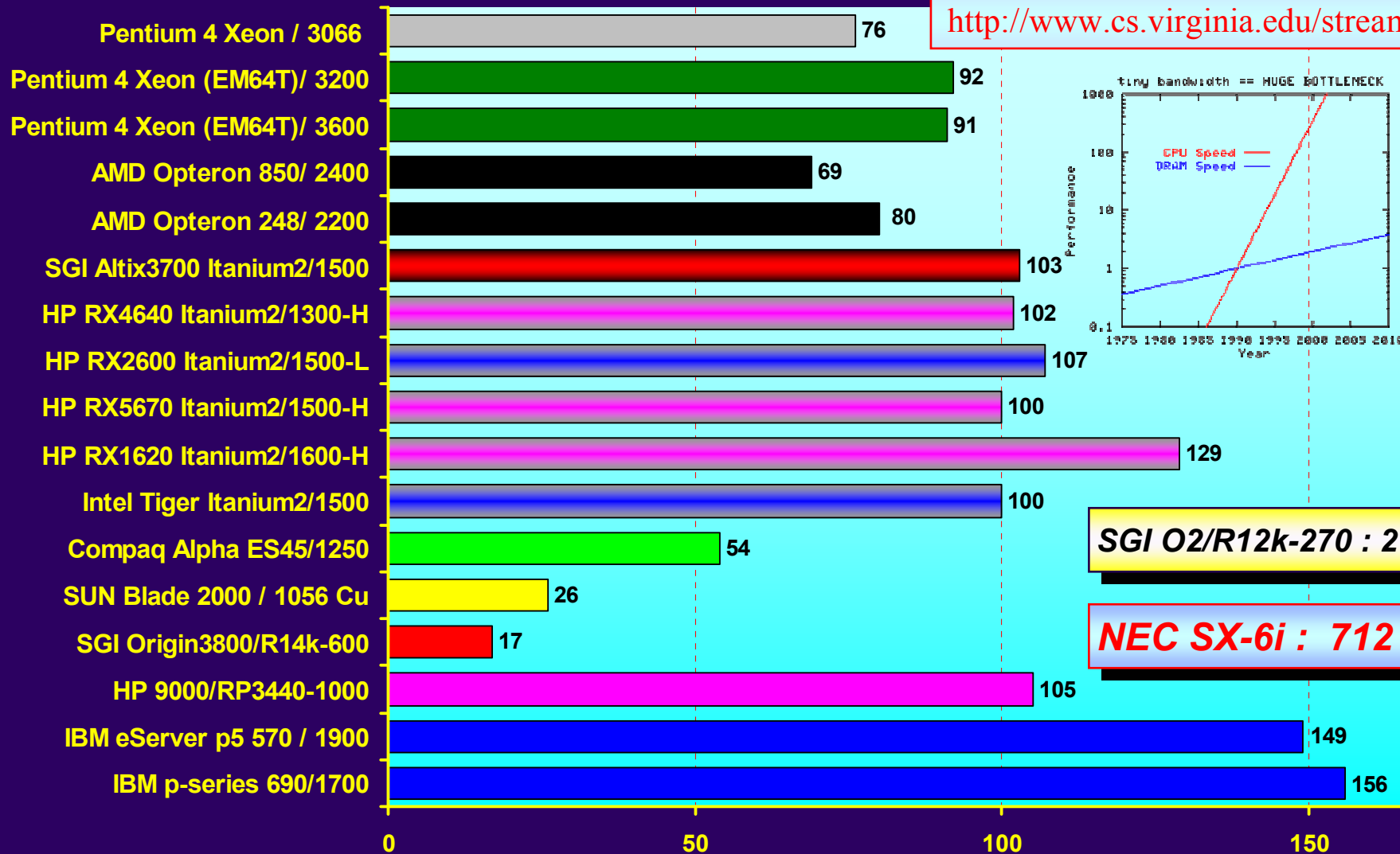
Chemistry Kernels - Jacobi Solver.

Performance relative to the HP RX5670 Itanium2/1.5GHz



STREAM: Measured Sustainable Memory Bandwidth in HPC (TRIAD)

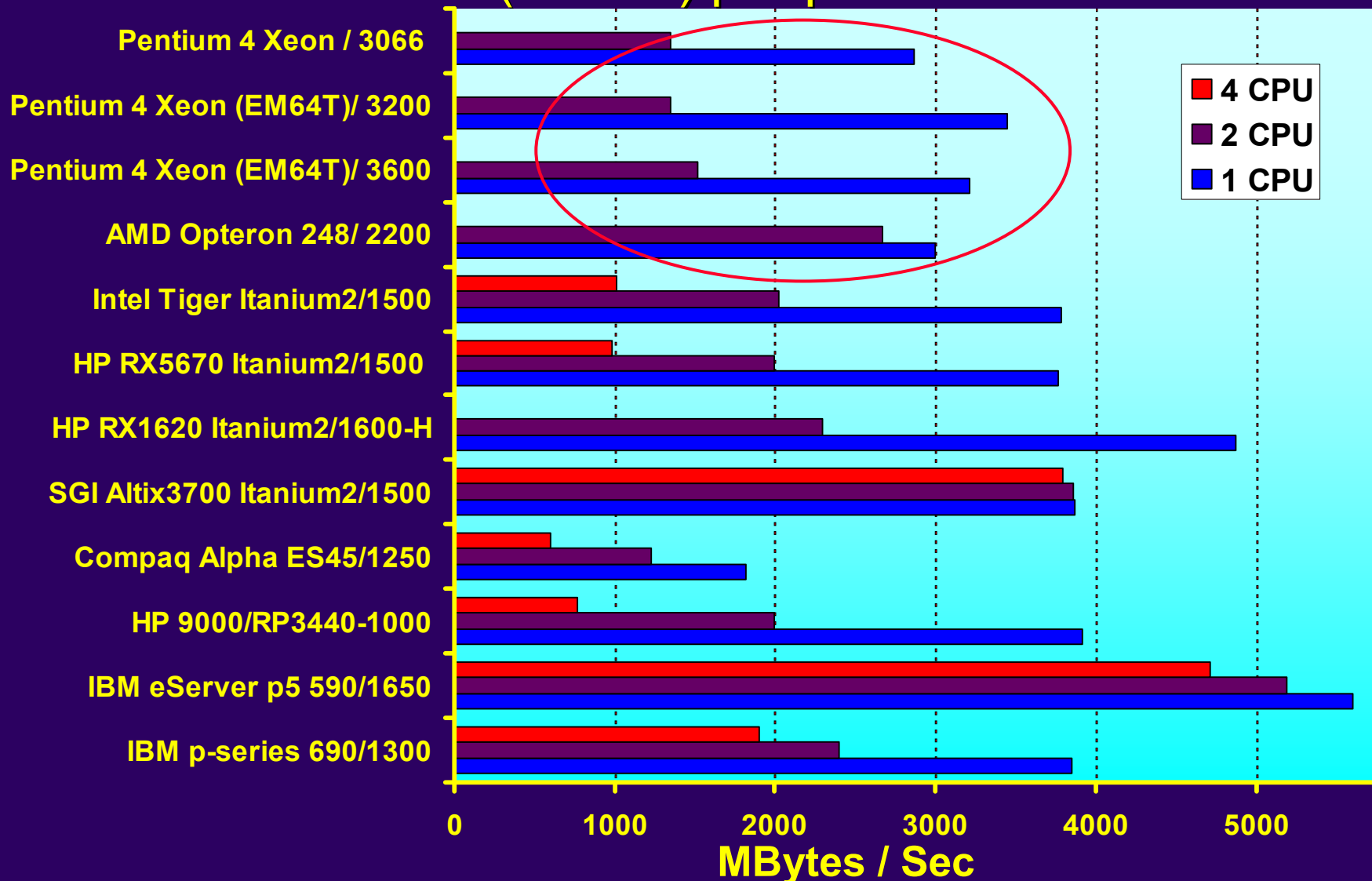
<http://www.cs.virginia.edu/stream>



SGI O2/R12k-270 : 2%

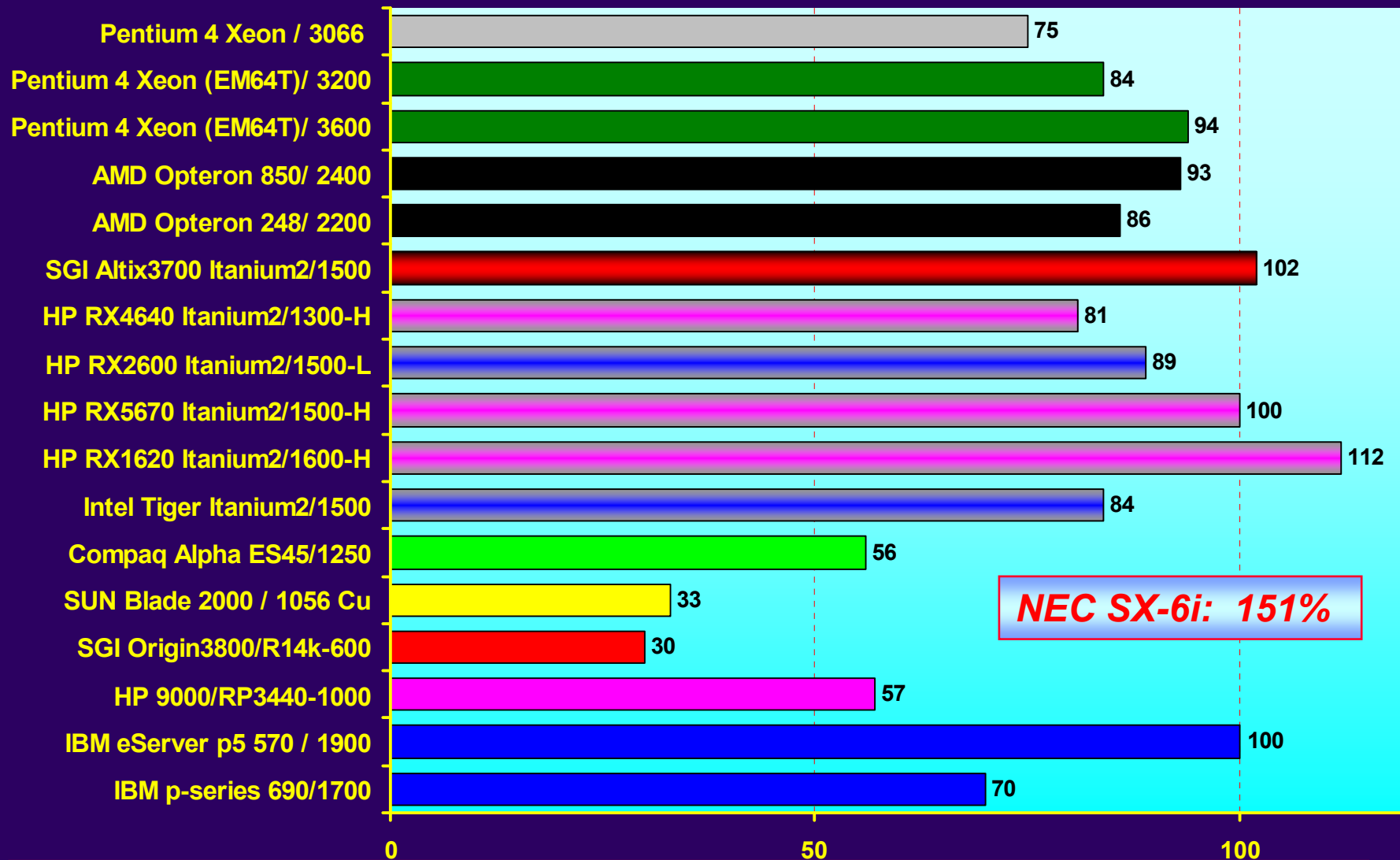
NEC SX-6i : 712 %

STREAM: Sustainable Memory Bandwidth (TRIAD) per process



Computational Chemistry Kernels.

Performance relative to the HP RX5670 Itanium2/1.5GHz



GAMESS-UK and DL_POLY Benchmarks

GAMESS-UK

DL_POLY

12 Typical QC Calculations

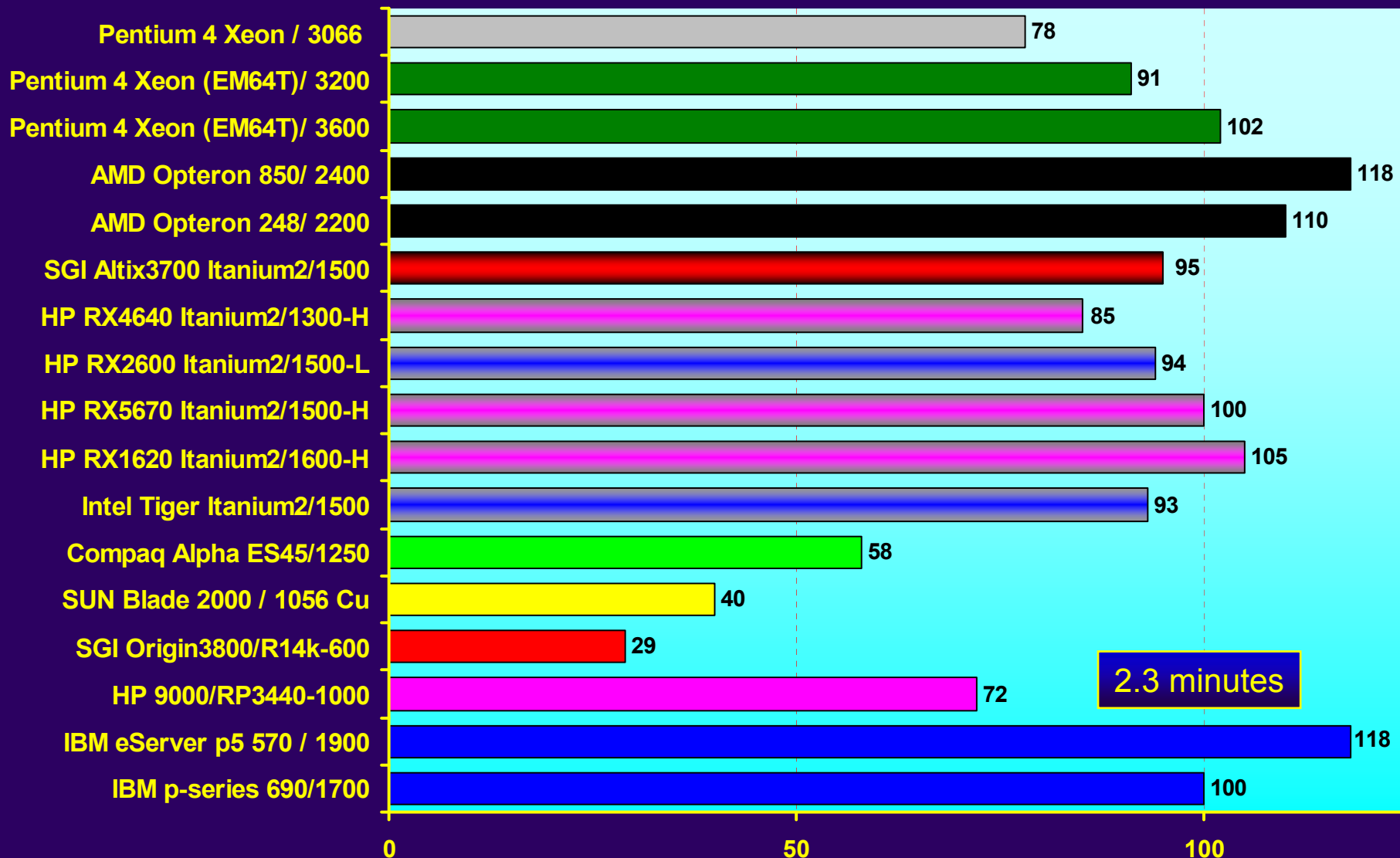
Module	Basis (GTOs)	Species
1. SCF	STO-3G (124)	Morphine
2. SCF	6-31G (154)	C ₆ H ₃ (NO ₂) ₃
3. ECP Geometry	ECPDZ (70)	Na ₇ Mg ⁺
4. Direct-SCF	6-31G (82)	Cytosine
5. CAS-geometry	TZVP (52)	H ₂ CO
6. MCSCF	EXT1 (74)	H ₂ CO
7. Direct-CI	EXT2 (64)	H ₂ CO/H ₂ +CO
8. MRD-CI (26M)	ECP (59)	TiCl ₄
9. MP2-geometry	6-31G* (70)	H ₃ SiNCO
10. SCF 2nd derivs.	6-31G (64)	C ₅ H ₅ N
11. MP2 2nd derivs.	6-31G* (60)	C ₄
12. Direct-MP2	DZP (76)	C ₅ H ₅ N

Six Typical Simulations

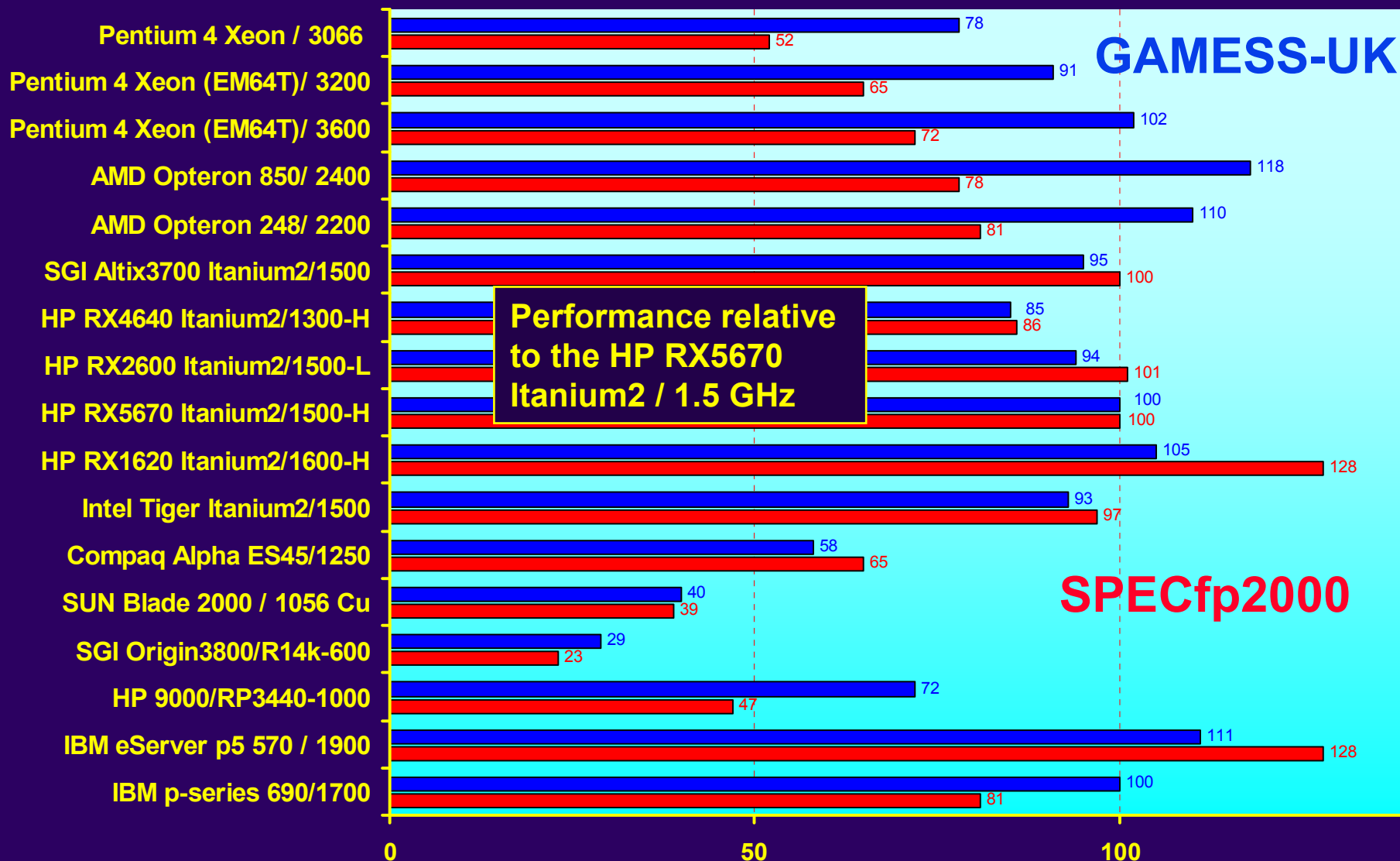
Simulation	Atoms	Time steps
1. Na-K disilicate glass	1080	300
2. Metallic Al with Sutton-Chen potential	256	8000
3. Valinomycin in 1223 water molecules	3837	100
4. Dynamic shell model water with 1024 sites	768	1000
5. Dynamic shell model MgCl ₂ with 1280 sites	768	1000
6. Model membrane, 2 membrane chains, 202 solute and 2746 solvent molecules	3148	1000

The GAMESS-UK Benchmark I. CPU

Performance relative to the HP RX5670 Itanium2/1.5GHz



SPECfp2000 and the GAMESS-UK Benchmark



The GAMESS-UK-99 Benchmark

10 Typical QC Calculations

<u>Module</u>	<u>Basis (GTOs)</u>	<u>Species</u>
1. Direct- SCF	6-31G (227)	Morphine
2. SCF	6-31G** (265)	C ₆ H ₃ (NO ₂) ₃
3. DFT B3LYP	6-311G* (167)	Cytosine
4. MCSCF	CC-PVTZ (100)	H ₂ CO
5. Direct-CI	CC-PVTZ (100)	H ₂ CO/H ₂ +CO
6. CCSD(T)	TZV+2d+1f (144)	C ₄
7. MP2-geometry	TZVP (105)	H ₃ SiNCO
8. SCF 2nd derivs.	6-311G** (144)	C ₅ H ₅ N
9. MP2 2nd derivs.	TZVP(C2d) (104)	C ₄
10. Direct-MP2	6-31G* (130)	Cytosine

Benchmark Time: 30.8 minutes on IBM p-series 690/pwr4 1.3 GHz

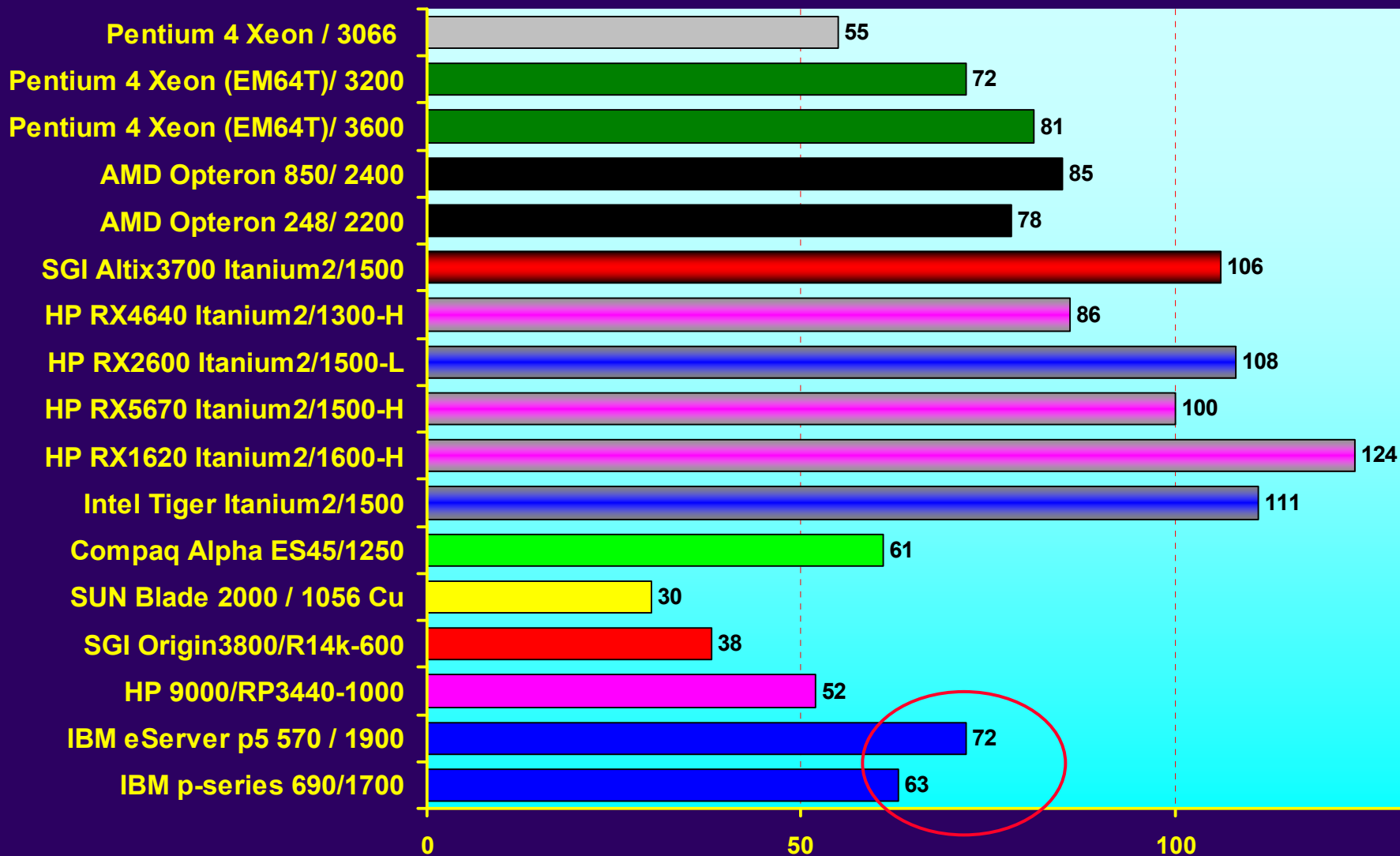
The GAMESS-UK-99 Benchmark

Performance relative to the HP RX5670 Itanium2/1.5GHz

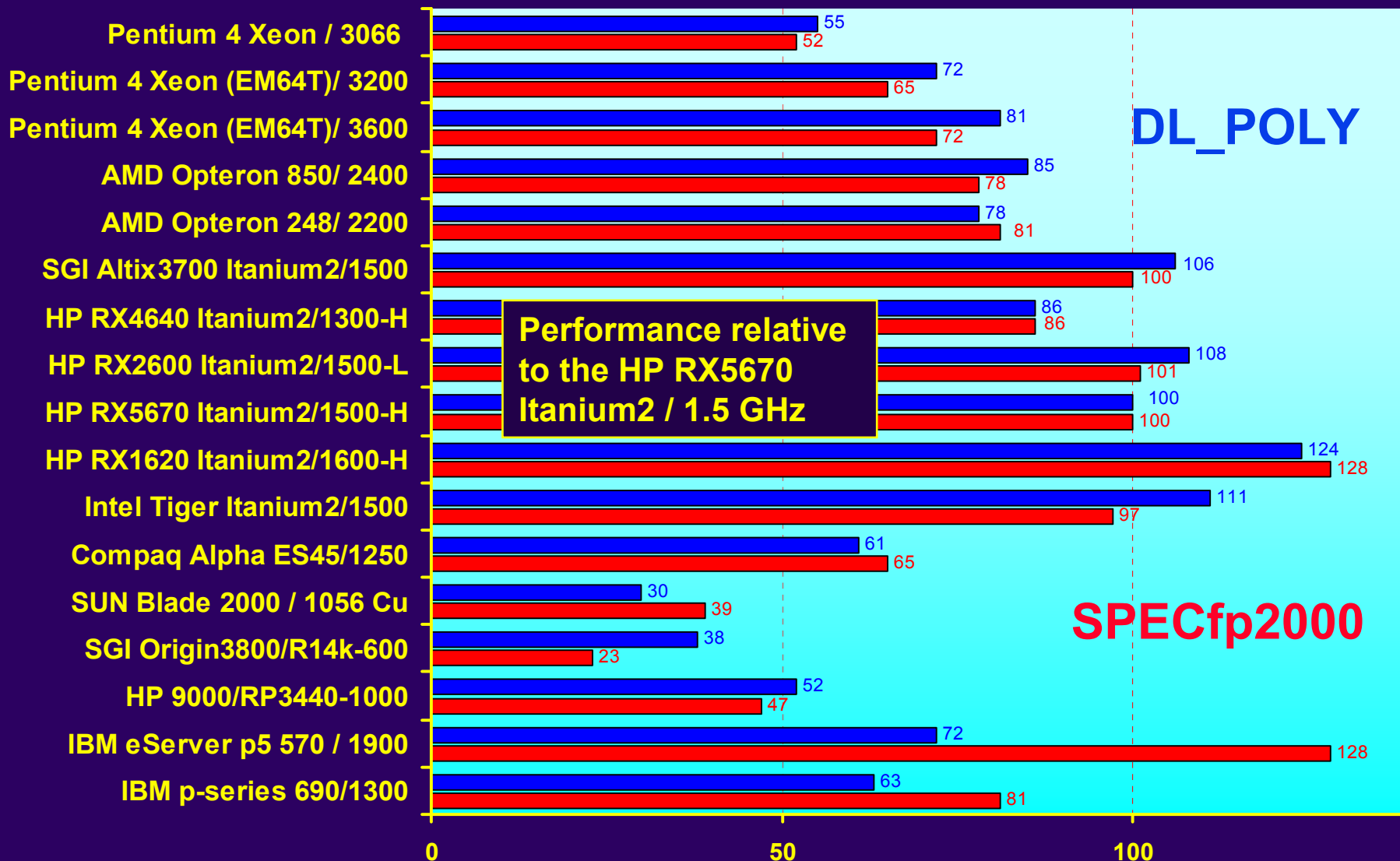


The DL_POLY Benchmark.

Performance relative to the HP RX5670 Itanium2/1.5GHz

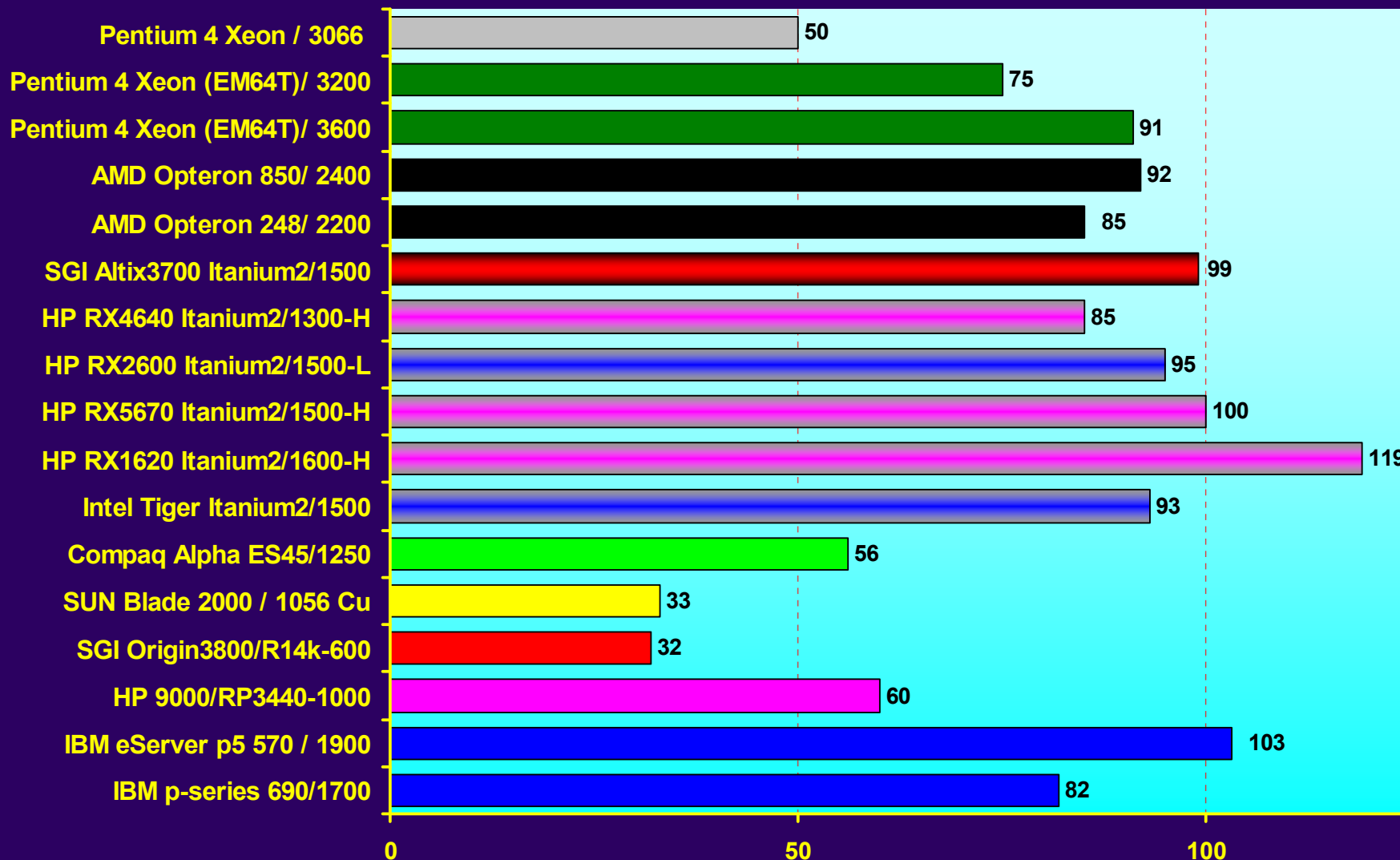


SPECfp2000 and the DL_POLY Benchmark



Summary Index relative to the HP RX5670 Itanium2/1.5GHz

The MATRIX-97, Chemistry Kernels, GAMESS-UK and DLPOLY Benchmarks



Computational Chemistry Rate Benchmark

- “Rate” Benchmark suite recently developed to incorporate:
 - Matrix “kernels” (MATRIX-97+)
 - Application packages (e.g. GAMESS-UK-99, DL_POLY+)
- Multi-component benchmark:
 - Matrix Operations / Matrix multiplication and matrix diagonalisation
 - Quantum Chemistry Calculations
 - Molecular Dynamics Calculations
- Rate Procedure:
 - For each benchmark (i) run n instances at once and take elapsed time (last to finish - first to start).
 - The rate for this benchmark is $R_i = n \times T_{ref} / T_i$
 - T_{ref} is the elapsed time on a reference system. (HP RX5670 Itanium2/1.5GHz scaled to a single processor ($n=1$) elapsed time of 100 units)
 - Take “the geometric mean” of all the benchmarks (with the same n).

Components of Chemistry Rate Benchmark

1. MATRIX OPERATIONS (MATRIX-97+)

- SPARSE Matrix Multiply BenchMark: Vector FORTRAN and DGEMM

- series of MMOs ($R = A \times B$) are performed involving matrices of increasing order:

- MATRIX-97+: 100, 200, ..., 1200 (B is sparse)

Memory bandwidth

- Diagonalisation Benchmark

- performance of 7 routines from mathematical libraries and QC codes:

- MATRIX-97+: 100, 200, ..., 600

- Q[†]HQ Benchmark

- involves use of library routines e.g. BLAS. Uses both a scalar and vector algorithm (DGEMM):

- MATRIX-97+: 100, 200, ..., 1000

-lblas

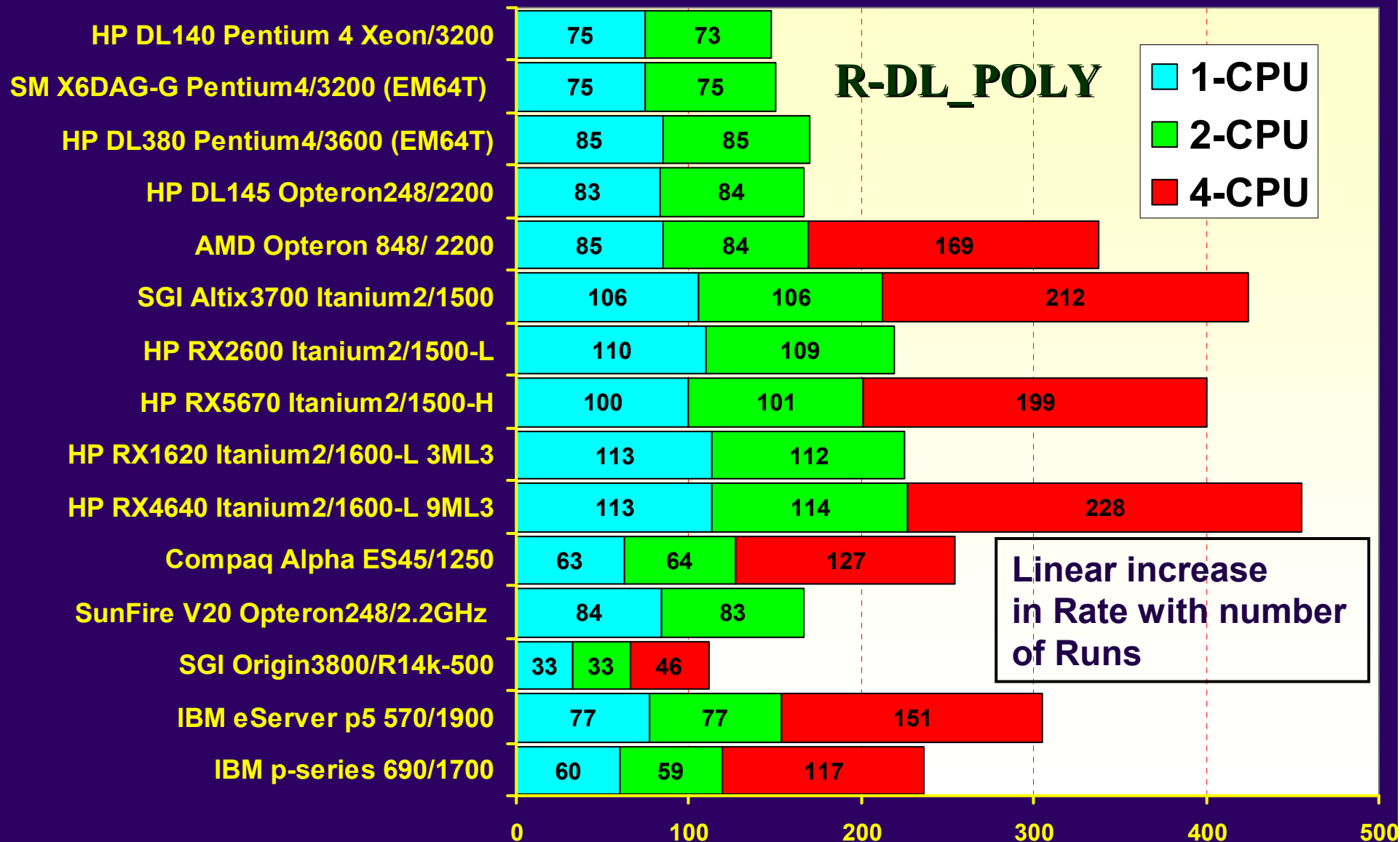
2. DLPOLY

- 5 simulations (increased no. of time steps)

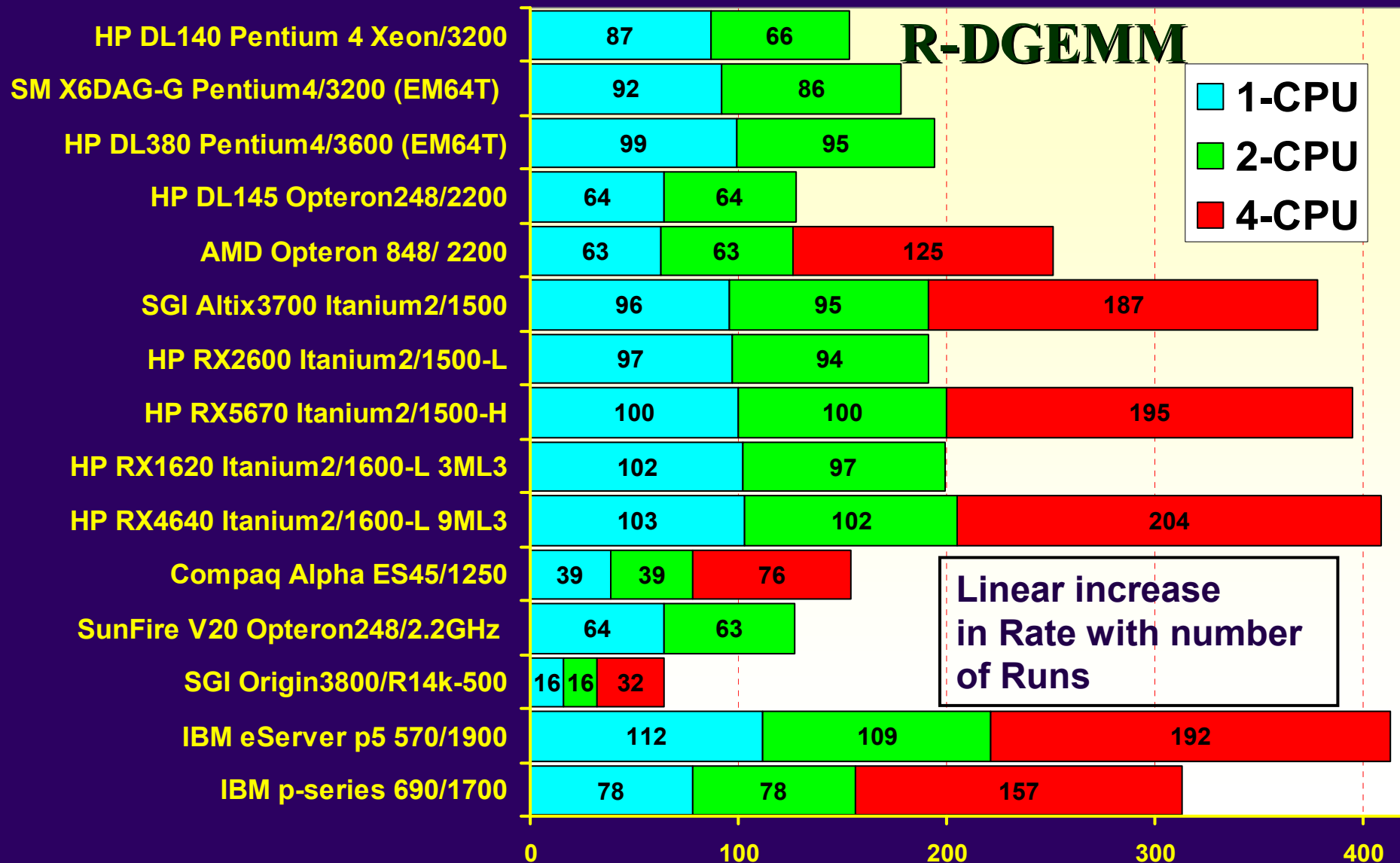
3. GAMESS-UK

- 8 Calculations (GAMESS_UK-99 : Direct- SCF, DFT B3LYP, MCSCF, Direct-CI, MP2-geometry, SCF 2nd derivs., MP2 2nd derivs., Direct-MP2)

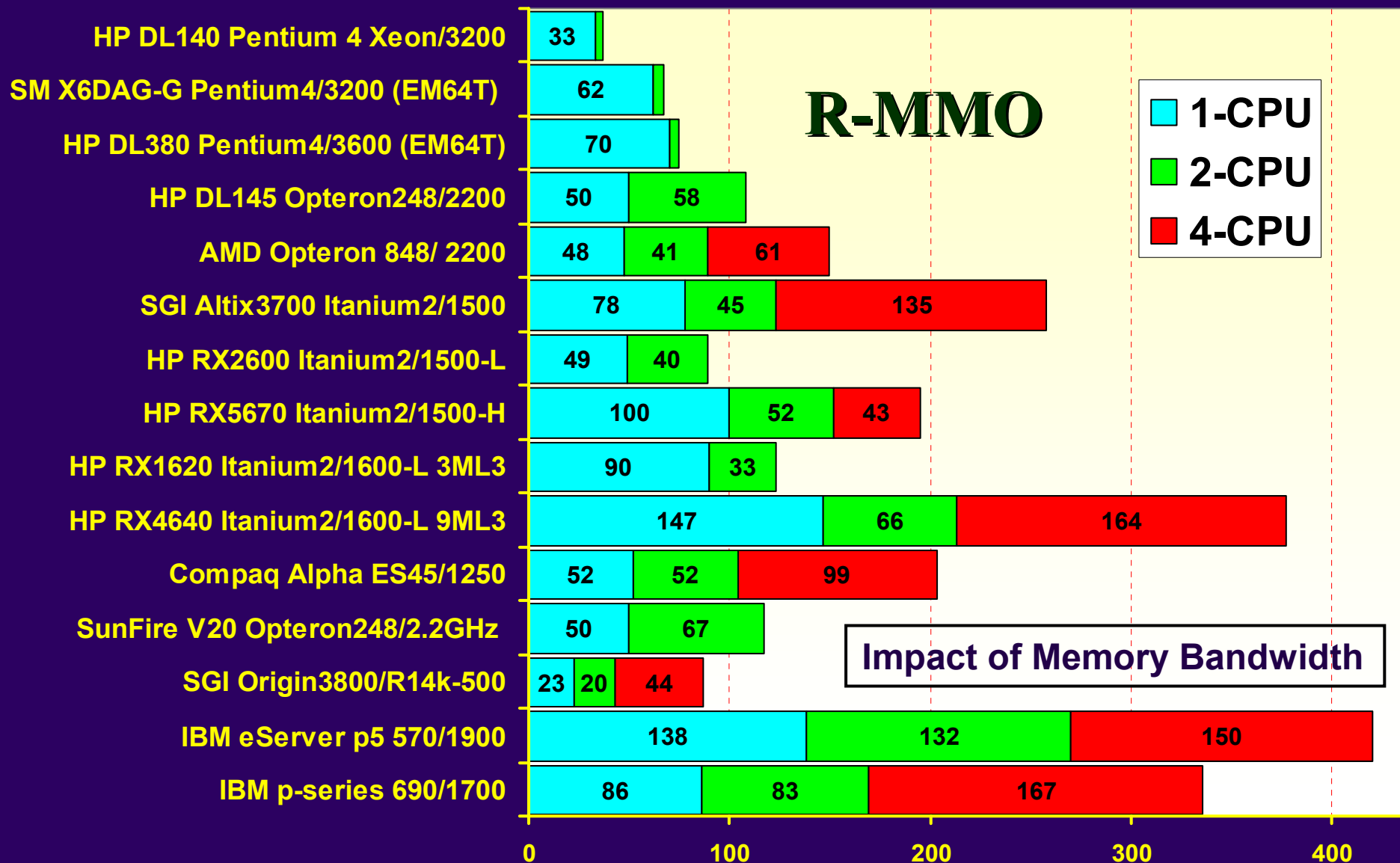
Rate Benchmark: DL_POLY Component



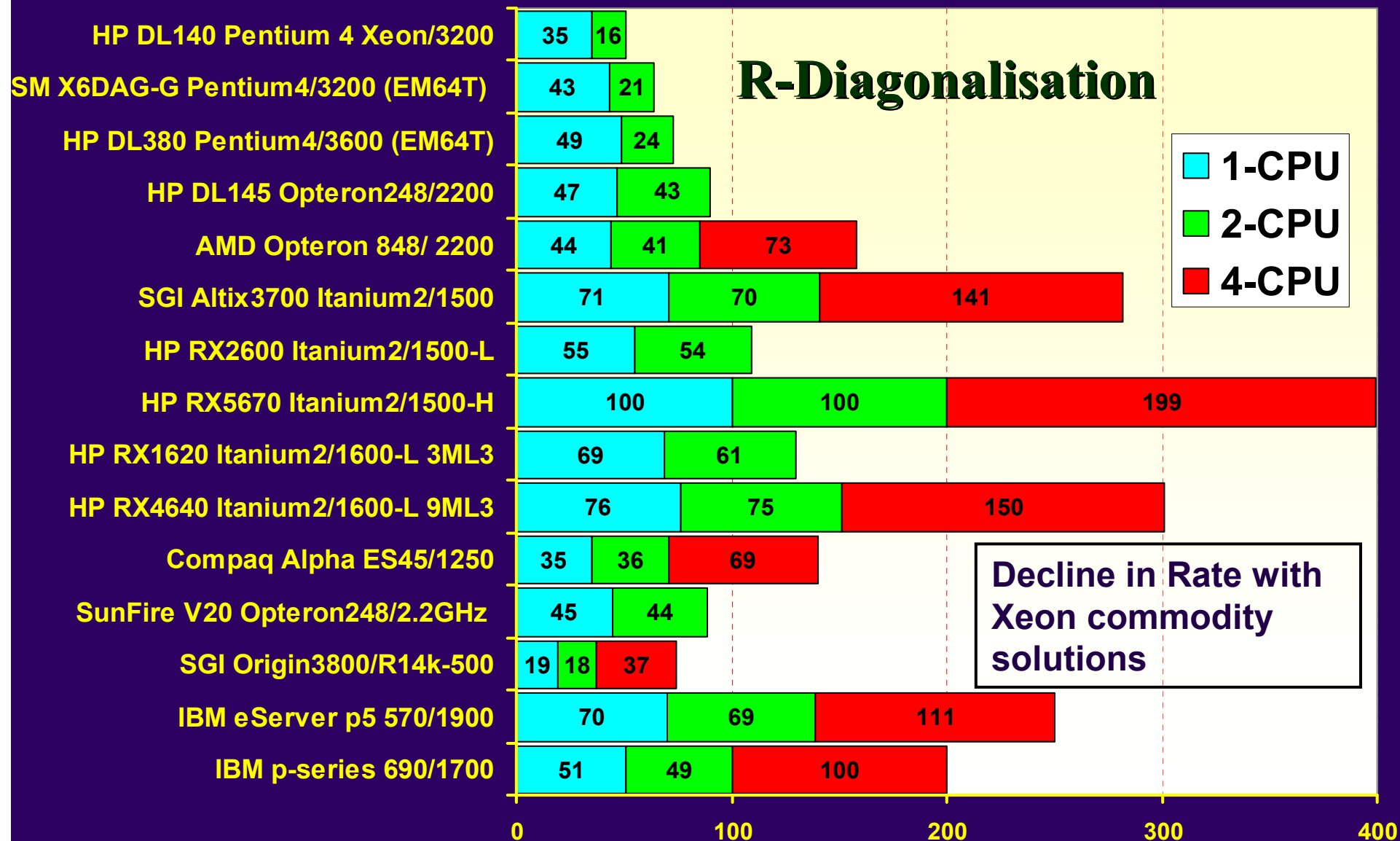
Rate Benchmark: DGEMM Component



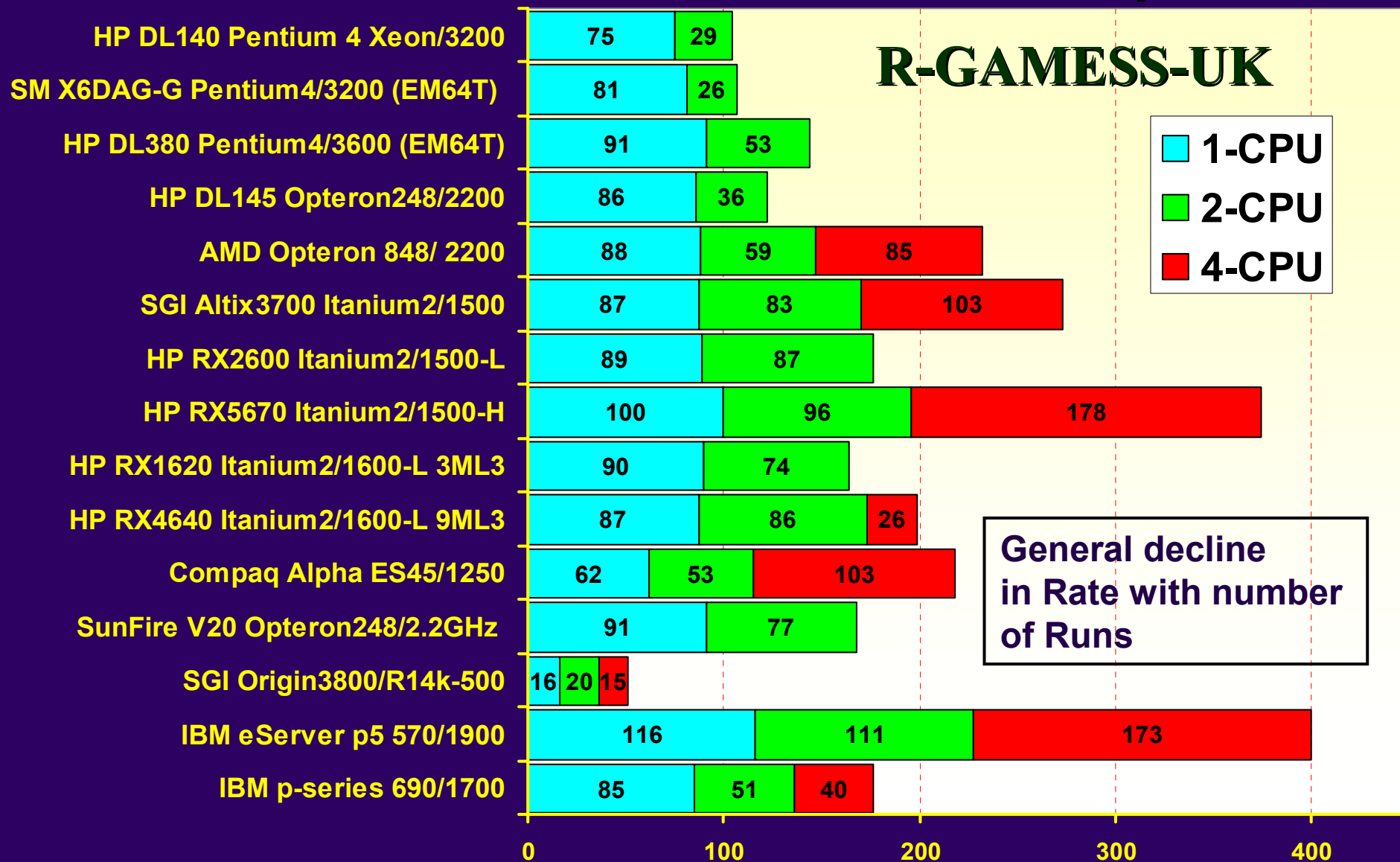
Rate Benchmark: MMO FORTTRAN



Rate Benchmark: Diagonalisation Component



Rate Benchmark: GAMESS-UK Component

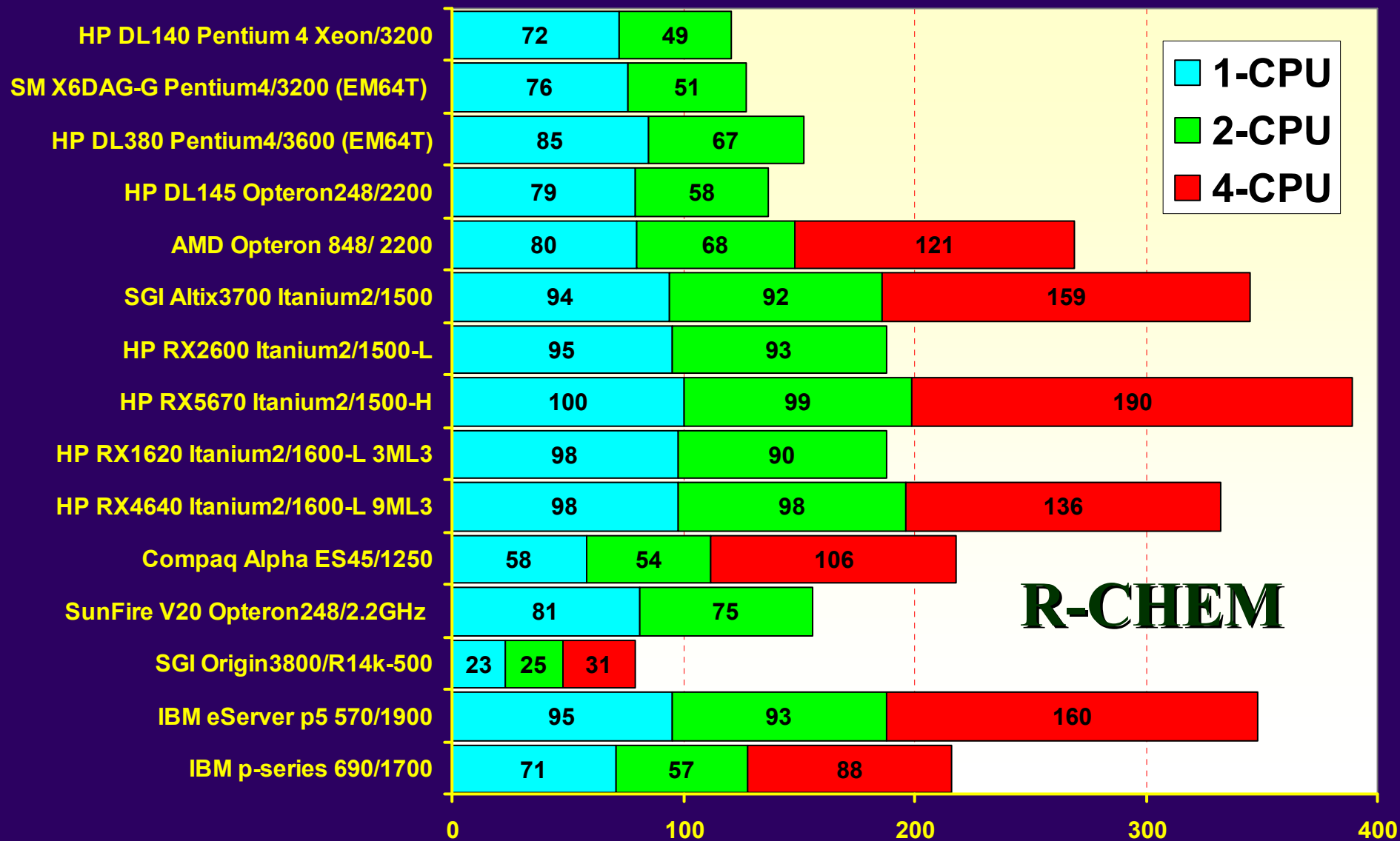


Computational Chemistry Rate Metric

- Chemistry Rate Metric:
 - For each component benchmark (i) run n instances at once and take elapsed time (last to finish - first to start).
 - Component rate $R_i = n \times T_{ref} / T_i$
 - T_{ref} is the elapsed time on the HP RX5670 Itanium2/1.5 GHz scaled to a single CPU time of 100 units.

$$R_{CHEM} = 0.1 \times R_{DGEMM} + \\ 0.1 \times R_{Diagonalisation} + \\ 0.4 \times R_{DLPOLY} + \\ 0.4 \times R_{GAMESS-UK}$$

Chemistry Rate Benchmark



Evaluation and Benchmarking of High-end and Commodity-based Systems

Parallel Systems and Capacity Computing

High-End Systems Evaluated

- Cray T3E/1200E (... historical ...)
 - 816 processor system at Manchester (CSAR), 600 Mz Alpha EV56 CPU, 256 MB
- IBM pseries 690 and pseries 690+ (Daresbury)
 - **IBM p690 (8-way LPAR'd nodes, 1280 X 1.3 GHz CPUs with colony, HPCx)**
 - **IBM p690+ (32-way nodes, 1600 X 1.7 GHz CPUs with HPS, HPCx- Phase2)**
- Compaq AlphaServer SC
 - 4-way ES40/667 A21264A (APAC) and 833 MHz SMP nodes (2 GB RAM);
 - **TCS1 system at PSC** (750 4-way ES45 nodes - 3,000 EV68 CPUs - 4 GB memory per node, 8MB L2 cache), Quadrics interconnect (5 usec latency, 250 MB/sec B/W)
- SGI Origin 3800
 - SARA (1000 CPUs) - Numalink with MIPS R14k/500 CPUs
- SGI Altix 3700
 - **Linux Cluster - Numalink with Itanium 2 1.3 GHz CPUs, 3MB L3 cache**
 - CSAR ("newton" 512 CPUs) and SARA ("aster" - 416 CPUs - 7 nodes)
 - **ORNL ("ram" 256 CPUs with Itanium 2 1.5 GHz CPUs, 6MB L3 cache)**

Commodity Systems (CSx)

Prototype / Evaluation Hardware

Systems	Location	CPUs	Configuration
CS1	Daresbury	32	PentiumIII / 450 MHz + FE (EPSRC)
CS2	Daresbury	64	24 X dual UP2000/EV67-667, QSNNet Alpha/LINUX cluster, 8 X dual CS20/EV67-833 ("loki")
CS3	RAL	16	Athlon K7 850MHz + myrinet
CS4	Sara	32	Athlon K7 1.2 GHz + FE
CS6	CLiC	528	PentiumIII / 800 MHz; fast ethernet (Chemnitzer Cluster)
CS7	Daresbury	64	AMD K7/1000 MP + SCALI/SCI ("ukcp")
CS8	NCSA	320	160 dual IBM Itanium/800 + Myrinet 2k ("titan")
CS9	Bristol	96	Pentium4 Xeon/2000 + Myrinet 2k ("dirac")
<u>Prototype Systems</u>			
CS0	Daresbury	10	10 CPUS, Pentium II/266
CS5	Daresbury	16	8 X dual Pentium III/933, SCALI

Commodity Systems (CSx) II.

Systems	Location	CPUs	Configuration
CS10	<i>Hull</i>	64	Pentium4 Xeon/2667 + Myrinet 2k ("eagle"), Streamline/SCORE
CS11	<i>Workstations</i>	32	Pentium4 Xeon/2667 + GbitEther, ScaMPI
CS12	<i>Essex</i>	48	Pentium4 Xeon/2400 + GbitEther ("sstream1"), Streamline/SCORE
CS13	<i>White Rose, Leeds</i>	256	Pentium4 Xeon/2200-2400 + M2k ("snowdon"), Streamline/SCORE
CS14	<i>NCSA</i>	1024	Pentium III Xeon/1000 + M2k ("platinum")
CS15	<i>SDSC</i>	128	Pentium III Xeon/ 800 + M2k ("meteor")
CS16	SDSC	256	dual-Itanium2/1.3 GHz + M2k ("Teragrid")
CS17	<i>Daresbury</i>	32	Pentium4 Xeon/2667 + GbitEther ("ccp1"), Streamline/SCORE
CS18	<i>Bradford</i>	78	Pentium4 Xeon/2800 + M2k/GbitE ("grendel")
CS19	<i>Daresbury</i>	64	dual-Opteron/246 2.0 GHz nodes + Infiniband, Gbit and SCI ("scaliwag")
CS20	<i>RAL</i>	256	dual-Opteron/248 2.2 GHz nodes + Myrinet ("scarf")

Applications Performance Overview

- **Serial (SPEC, DL) & Communication Benchmarks**
- **Parallel Applications Performance**

1. Computational Chemistry:
Molecular Simulation & Electronic Structure
2. Computational Materials Science
3. **Atomic & Molecular Physics**
4. Computational Engineering
5. **Environmental Modelling**

- Capacity-based group solution
- Issues of Cost effectiveness
- On e.g. 128-256 CPU cluster, modal job size is ~ 32 CPUs
- Increasing trend to hierarchical clusters - Gbit network with HEC core (with e.g. myrinet)

**Capability and Capacity Computing
Commodity vs. Proprietary Solutions**

Performance Metrics: 1999-2001

Attempted to quantify delivered performance from the Commodity-based systems against MPP (CSAR Cray T3E/1200E) and ASCI-style SMP-node platforms (e.g. SGI Origin 3800) i.e.

Performance Metric (% 32-node Cray T3E)

$$T(32\text{-nodes Cray T3E/1200E}) / T(32\text{ CPUs}) \text{ CSx}$$

$$[T_{32\text{-node T3E}} / T_{32\text{-node CS1 Pentium III/450 + FE}]$$

$$T_{32\text{-node T3E}} / T_{32\text{-node CS6 Pentium III/800 + FE}$$

$$T_{32\text{-node T3E}} / T_{32\text{-CPU CS2 Alpha Linux Cluster + Quadrics}$$

Performance Metrics: 2002

Performance Metric (% 32-node AlphaServer SC [PSC])

$$T(32\text{-CPUs AlphaServer SC ES45/1000}) / T(32\text{ CPUs}) \text{ CSx}$$

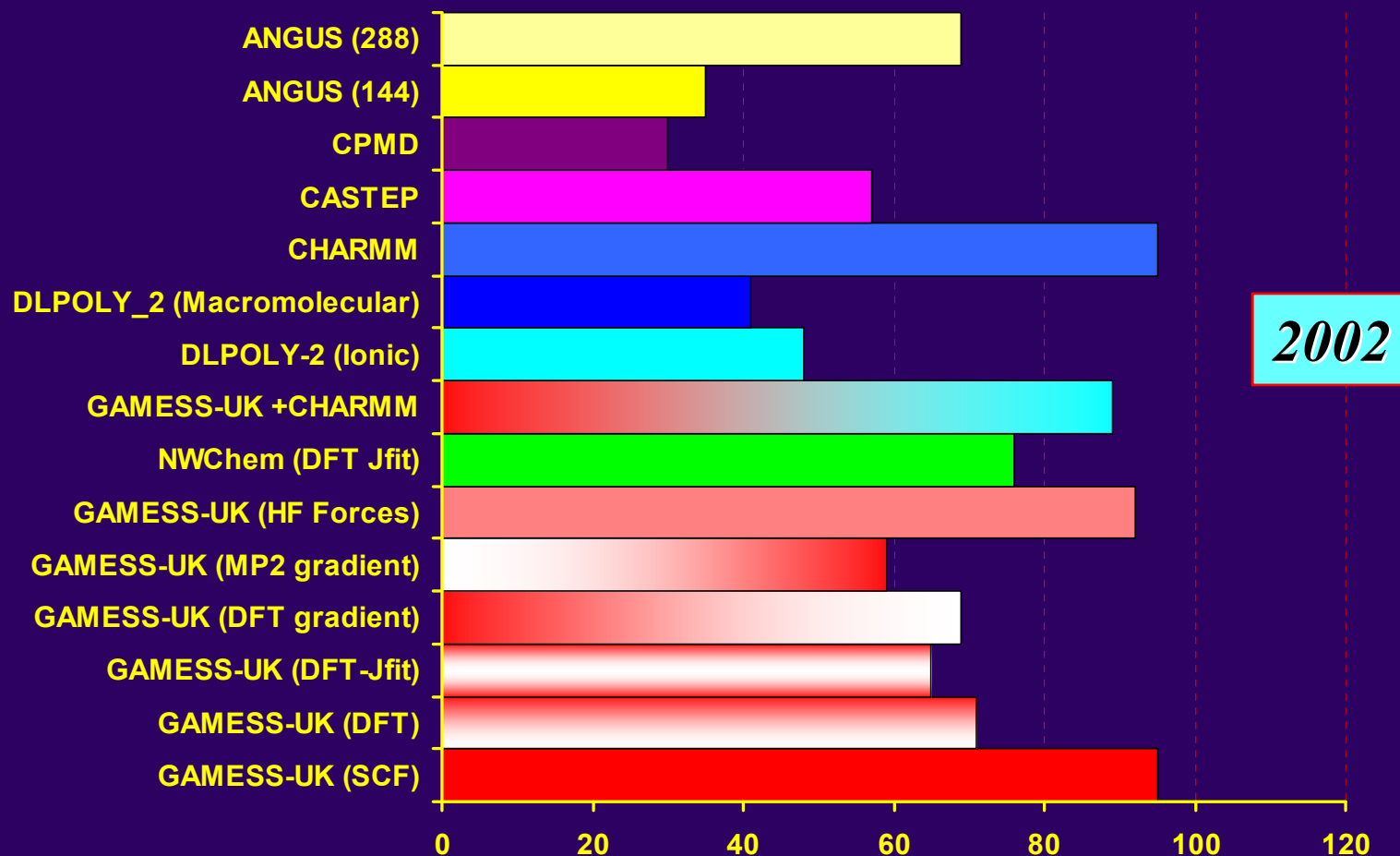
$$T_{32\text{-CPU AlphaServer ES45}} / T_{32\text{-CPU CS9 Pentium 4 Xeon / 2000 + Myrinet 2k}$$

Commodity Comparisons with High-end Systems

% of 32 CPUs of Compaq AlphaServer SC ES45/1000

Cluster CS9
Pentium4/2000 Xeon + Myrinet

CS9 - 66% of ES45/1000



Performance Metrics: 2004

Attempt to quantify delivered performance from current Commodity-based systems against high-end platforms: SGI Altix 3700/Itanium2 1.3 GHz (CSAR service) and IBM p690+ (HPCx service) i.e.

Performance Metric (% 32-node SGI Altix 3700/Itanium 2 1.3 GHz)

$T_{32\text{-CPU SGI Altix 3700/Itanium2 1.3GHz}} / T_{32\text{ CPUs } CSx}$

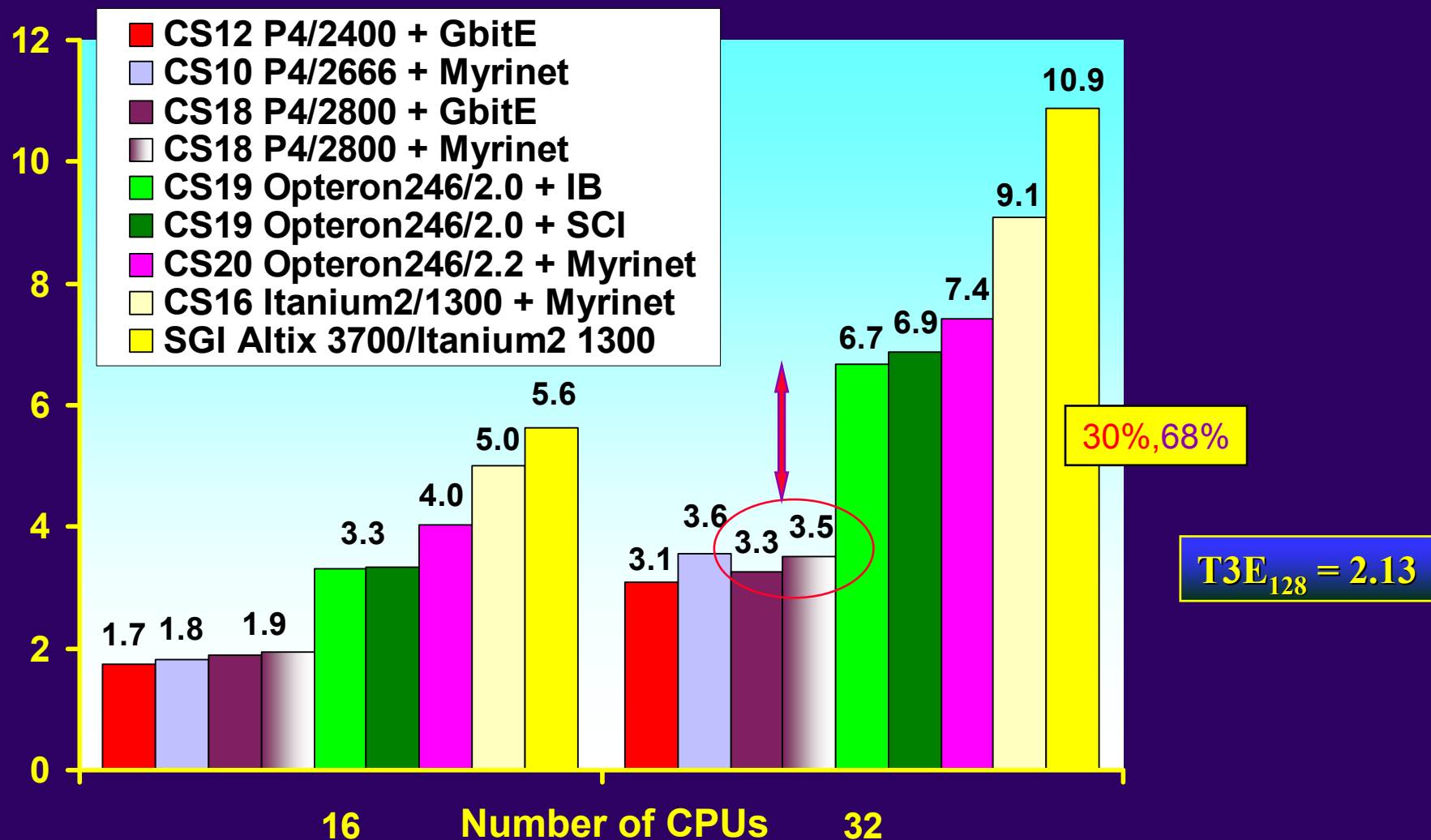
$T_{32\text{-CPU SGI Altix 3700}} / T_{32\text{-CPU CS20 Opteron 248 / 2800 + Myrinet 2k}$

$T_{32\text{-CPU SGI Altix 3700}} / T_{32\text{-CPU CS18 Pentium 4 Xeon / 2800 + Gbit Ethernet}$

DL_POLY V2: High-end and Commodity-based Systems

Bench 4: NaCl; 27,000 ions, Ewald, 75 time steps, Cutoff=24Å

Performance

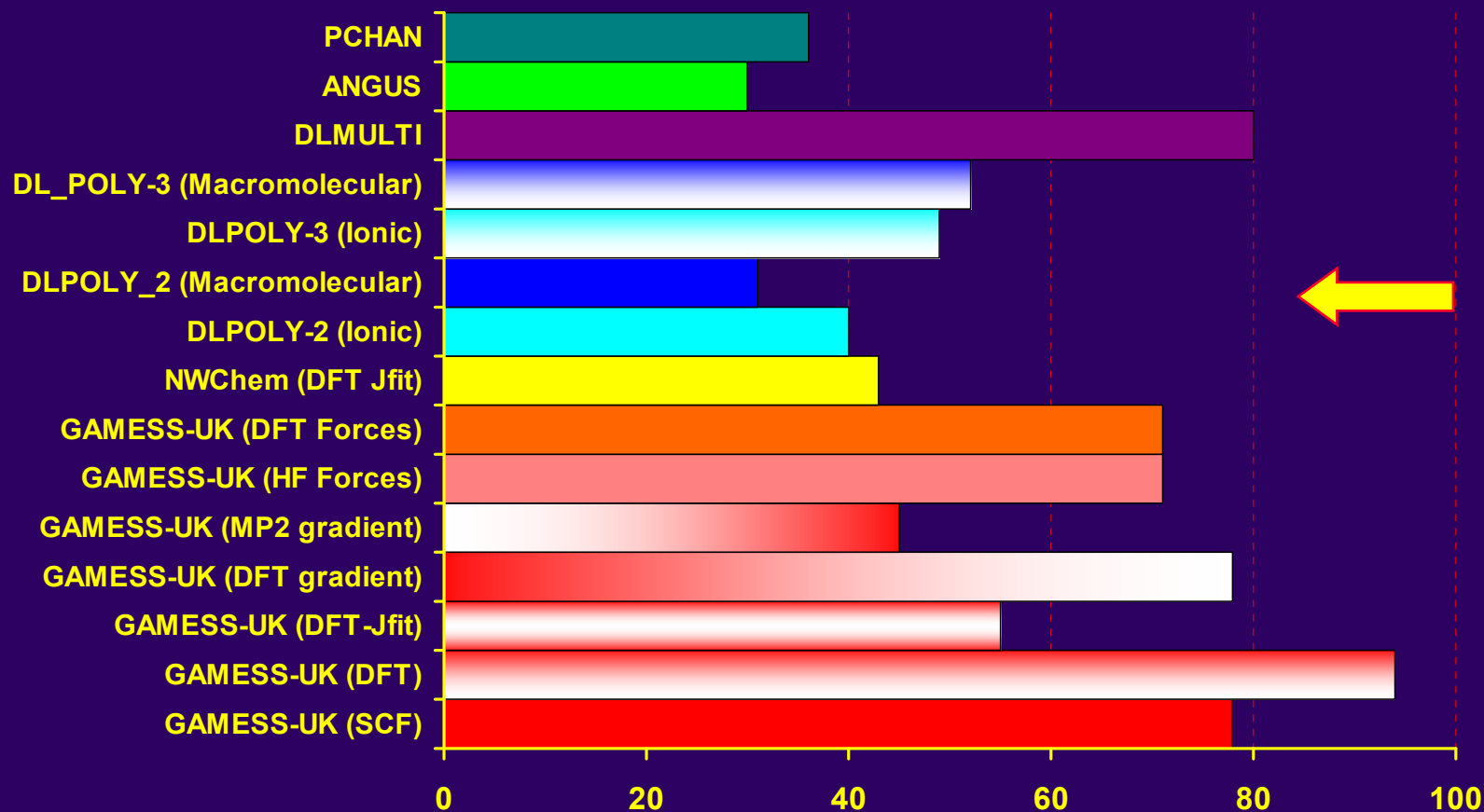


Commodity Comparisons with High-end Systems

% of 32 CPUs of SGI Altix 3700 / 1300

Cluster CS18
Pentium4/2800 Xeon + Gbit Ethernet

CS18 - 49% of Altix

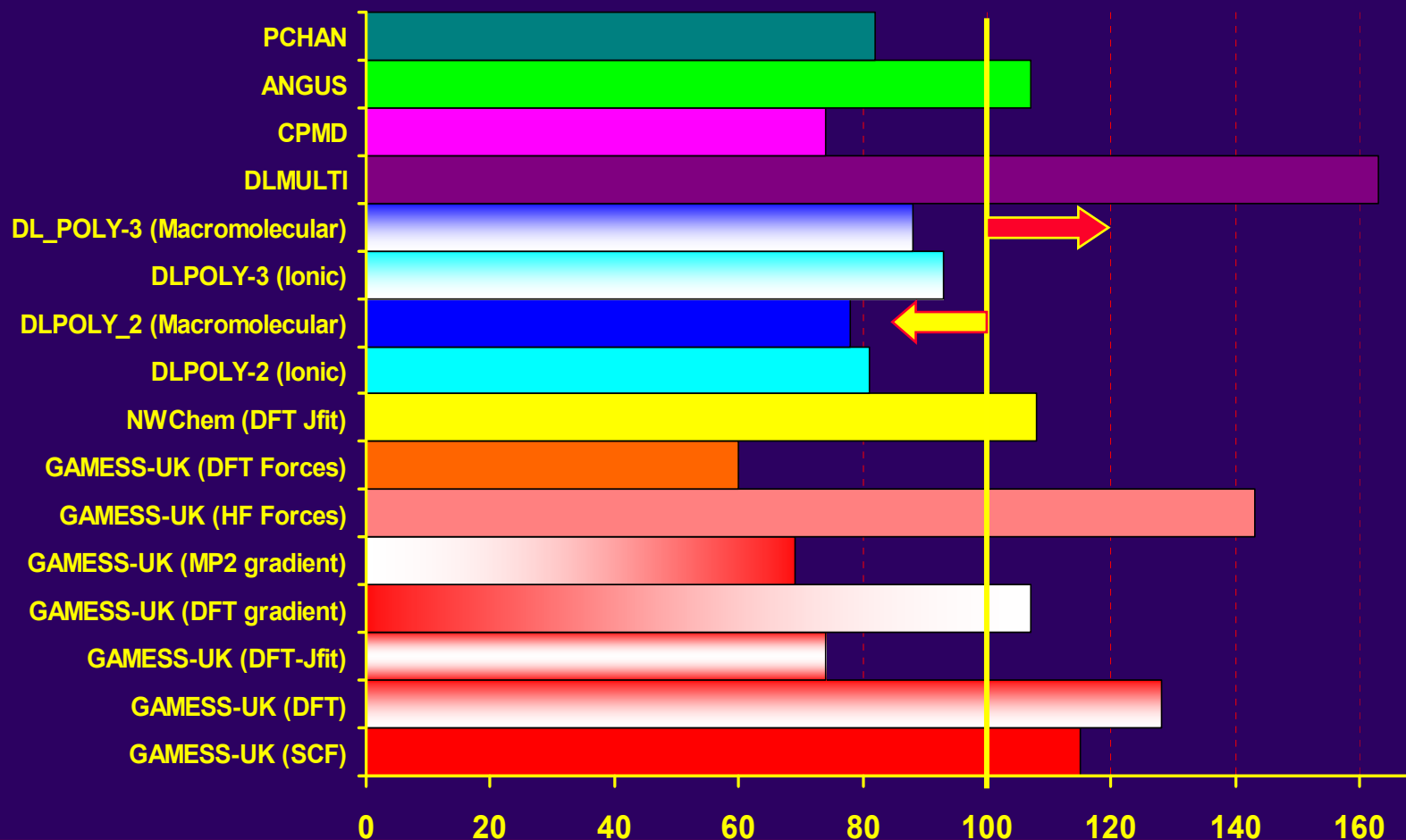


Commodity Comparisons with High-end Systems

% of 32 CPUs of SGI Altix 3700 / 1300

Cluster CS20
 AMD Opteron 248/2.2 + Myrinet

CS20 - 100% of Altix



SUMMARY

- Processor Performance Overview
 - Single-processor performance, Performance Metrics
- SPECfp and Computational Chemistry Benchmark (serial)
 - Matrix'89 and Matrix'97 kernels (MMO, diagonalisation), Application kernels" (SCF, MD, QMC and JACOBI + STREAM), Application packages (GAMESS-UK, DL_POLY)
- Increasing importance of Rate-based benchmarks:
 - SPECfp_rate and Chemistry Rate Benchmark
- Machine COSTS vs. Performance: URLs:
 - Powerpoint presentation and Paper:
<http://www.cse.clrc.ac.uk/disco/hw-perf.shtml>
- Benchmarking & Evaluation of Commodity-based Systems
 - CS20 Opteron248/2200 cluster with Myrinet delivers on average 100% of SGI Altix 3700/1300.
 - Cost effectiveness of the Clusters (e.g., CS18) with Gbit Ethernet - delivers 49% of the SGI Altix 3700/1300.