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Parallel Computing Timeline

Compiled by Robert Keller

CS 156

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Sources

- http://www.computerhistory.org/timeline
- wikipedia

1960: Instruction Pipelining, Memory Interleaving

- IBM “Stretch” (7030)
- 1.2 MIPS
- about 250,000 64-bit words of memory

Stretch maintenance console

1964: Parallelism in Instruction Streams

IBM System/360

- IBM announced the System/360, a family of six mutually compatible computers and 40 peripherals that could work together. The initial investment of $5 billion was quickly returned as orders for the system climbed to 1,000 per month within two years. At the time IBM released the System/360, the company was making a transition from discrete transistors to integrated circuits, and its major source of revenue moved from punched-card equipment to electronic computer systems.

360 mod 91 actually came a little later (1967?)

CDC 6600

- CDC´s 6600 supercomputer, designed by Seymour Cray, performed up to 3 million instructions per second — a processing speed three times faster than that of its closest competitor, the IBM Stretch. The 6600 retained the distinction of being the fastest computer in the world until surpassed by its successor, the CDC 7600, in 1968. Part of the speed came from the computer´s design, which had 10 small computers, known as peripheral processors, funneling data to a large central processing unit.

CDC 6600

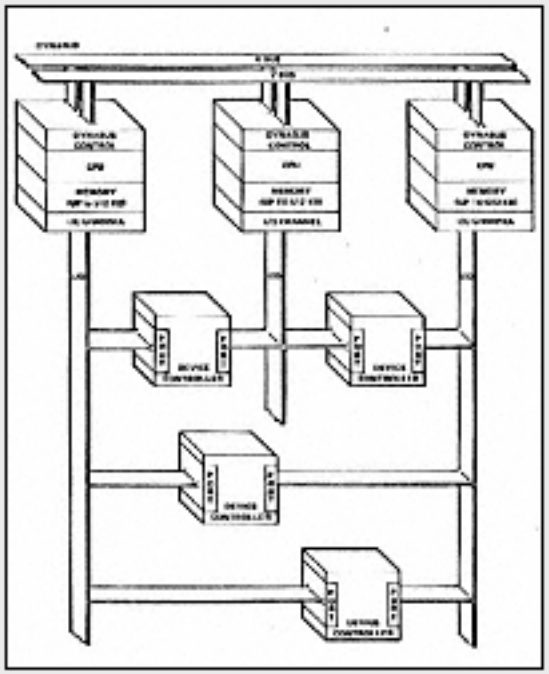
1966: SIMD Machine

ILLIAC IV

- The Department of Defense Advanced Research Projects Agency contracted with the University of Illinois to build a large parallel processing computer, the ILLIAC IV, which did not operate until 1972 at NASA´s Ames Research Center. The first large-scale array computer, the ILLIAC IV achieved a computation speed of 200 million instructions per second, about 300 million operations per second, and 1 billion bits per second of I/O transfer via a unique combination of parallel architecture and the overlapping or "pipe-lining" structure of its 64 processing elements.

  This photograph shows one of the ILLIAC´s 13 Burroughs disks, the debugging computer, the central unit, and the processing unit cabinet with a processing element.

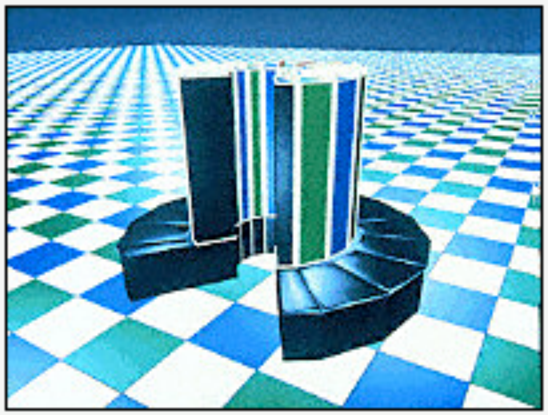
1975: Fault Tolerance



Tandem-16

- Tandem computers tailored its Tandem-16, the first fault-tolerant computer, for online transaction processing. The banking industry rushed to adopt the machine, built to run during repair or expansion.

1976: Vector Processor



Cray I

- The Cray I made its name as the first commercially successful vector processor. The fastest machine of its day, its speed came partly from its shape, a C, which reduced the length of wires and thus the time signals needed to travel across them.

Project started:	1972
Project completed:	1976
Speed:	166 million floating-point operations per second
Size:	58 cubic feet
Weight:	5,300 lbs.
Technology:	Integrated circuit
Clock rate:	83 million cycles per second
Word length:	64-bit words
Instruction set:	128 instructions

1982: Parallel Vector Processor

- The Cray XMP, first produced in this year, almost doubled the operating speed of competing machines with a parallel processing system that ran at 420 million floating-point operations per second, or megaflops. Arranging two Crays to work together on different parts of the same problem achieved the faster speed. Defense and scientific research institutes also heavily used Crays.

1983: Hypercube Interconnect

- Cosmic Cube at Caltech
- Used 8086 chips

- iPSC at Intel
- Used 8086 chips, multiple ethernet cards to interconnect
- (Example: “Henry” on 2nd floor Sprague)

- nCUBE corp.: 1024 custom architecture

1986: Connection machine

Connection Machine

- Daniel Hillis of Thinking Machines Corp. moved artificial intelligence a step forward when he developed the controversial concept of massive parallelism in the Connection Machine. The machine used 16,000 processors and could complete several billion operations per second. Each processor had its own small memory linked with others through a flexible network that users could alter by reprogramming rather than rewiring.

  The machine´s system of connections and switches let processors broadcast information and requests for help to other processors in a simulation of brainlike associative recall. Using this system, the machine could work faster than any other at the time on a problem that could be parceled out among the many processors.

1987: Butterfly interconnect

- BBN Butterfly
- NUMA architecture

1987: Parallel Inference Machine

Japanese 5th Generation Project

1991: Distributed Shared Memory

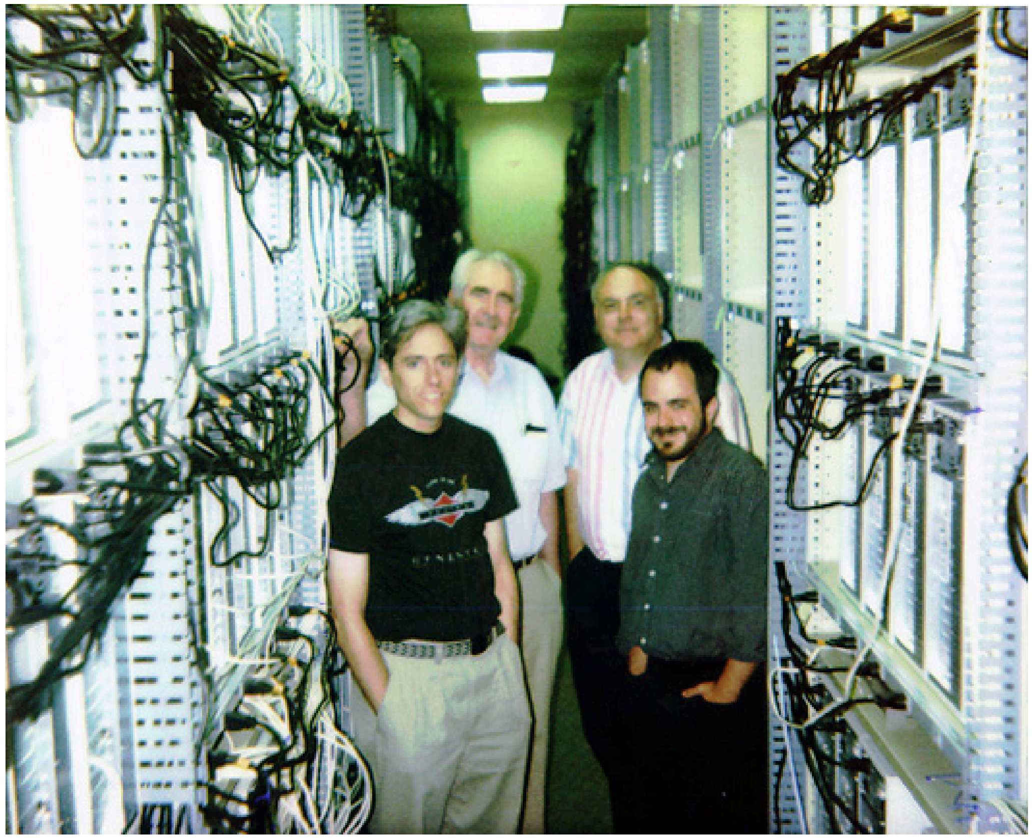
- Stanford DASH

1995: Cray T3E-1200

- Distributed memory
- 32 to 2048 processing elements (PEs)
- 8 Million words (64 MB) per PE
- PE: DEC Alpha, 1200 Mflops
- 2.4 teraflops maximum
- 3-D torus interconnect
- interprocessor comm. rate: 500 MB

- starting at the paltry sum of $630,000

1996: NOW (Network of Workstations) Beowulf Cluster



John Koza's 1000 node cluster, 1999
Used for Genetic Programming

1997: ASCI Red

- Intel i4640 nodes
- Housed at Sandia NL
- 666 MOPs peak per node
- 606 GB memory

2003: IBM SP3

- 1-8 processors, shared memory
- up to 16 GB memory
- networkable to 512 processors
- PE: IBM RS/6000
- 2-level coherent cache
- 14.2 GB/s crosspoint switch
- Cost for 128 PE version:
  only $8,614,441

2006: SGI Origin 3000 series

- 16-512 processors
- up to 1 TB shared memory
- R12000 processors, 300 MHz
- NUMA architecture
- 38.4 Gflops for 64 processors
- 716 GB/s system bandwidth
- Cost starting around $300k

2005-08:

Red Storm (Cray-Designed) at Sandia

Operational Time Frame	2005	2006	2008
Theoretical Peak (TF)	41.47	124.42	284.16
HPL Performance (GF)	36190 on 10,880 processors	101400 on 26,544 processors	204200 on 38,208 processors
Architecture	distr memory MIMD	distr memory MIMD	distr memory MIMD
Number of compute processors	10,368	25,920 (12,960 nodes)	38,400 (12,960 nodes)
Number of service/IO processors	256 + 256	320+320	320+320
Processor	AMD Opteron™ @ 2.0 GHz	AMD dual core Opteron™ @ 2.4 GHz	6720 AMD dual-core Opteron™ @ 2.4 GHz 6240 AMD quad-core Opteron™ @ 2.2 GHz
Total Memory	33.38TB	39.19 TB	78.75 TB
System Memory B/W	57.97 TB/s	78.12 TB/s	126.29 TB/s
[illegible]	[illegible]	[illegible]	[illegible]

2004-2011: IBM Blue Gene

The first computer in the Blue Gene series, Blue Gene/L, developed through a partnership with Lawrence Livermore National Laboratory (LLNL), originally had a theoretical peak performance of 360 TFLOPS.

. . .

The archetypal Blue Gene/Q system called Sequoia will be installed at Lawrence Livermore National Laboratory in 2011 as a part of the Advanced Simulation and Computing Program running nuclear simulations and advanced scientific research.

It will consist of 98,304 compute nodes comprising 1.6 million processor cores and 1.6 PB memory in 96 racks covering an area of about 3000 square feet, drawing 6 megawatts of power.

2007: Cray XT5 (Jaguar, Kraken)

CRAY XT5

Cray XT5 – Scalable Computing at Work

As the single most scalable Linux supercomputer, the Cray XT5™ system combines unprecedented sustained application performance with exceptional manageability and reliability, and lower cost of ownership for customers.

Using powerful AMD Opteron™ processor cores, the Cray XT5 system supports both Cray XT4™ blades for optimized compute/interconnect balance and the new Cray XT5 blades optimized for memory-intensive and/or compute-biased workloads.

Oak Ridge National Laboratory's (ORNL) "Jaguar" supercomputer, a Cray XT5 system, is the fastest in the world for open science.

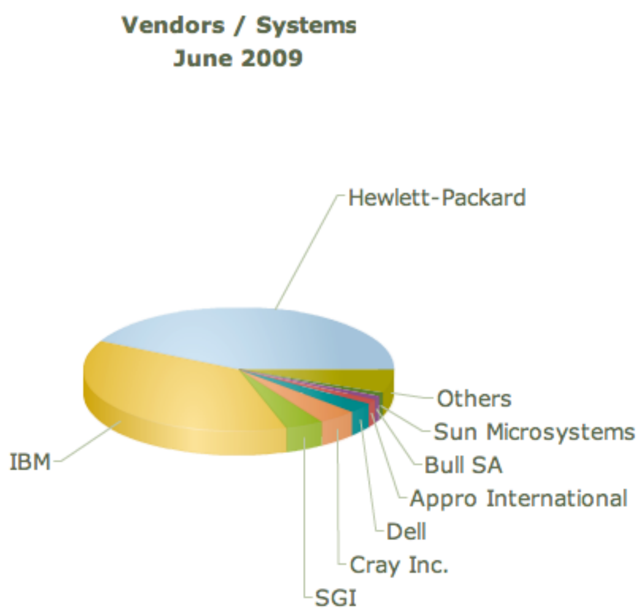
Request a Quote

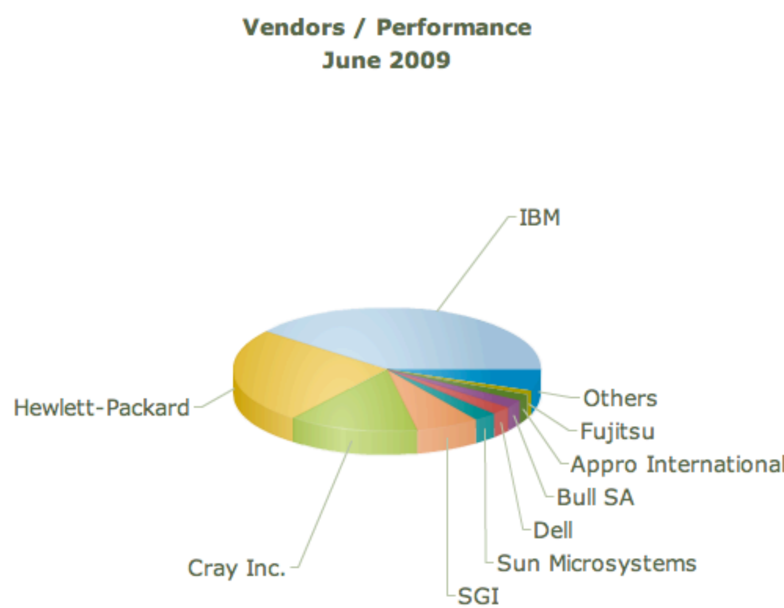
2009: Current Top 500 SC Sites

http://www.top500.org/

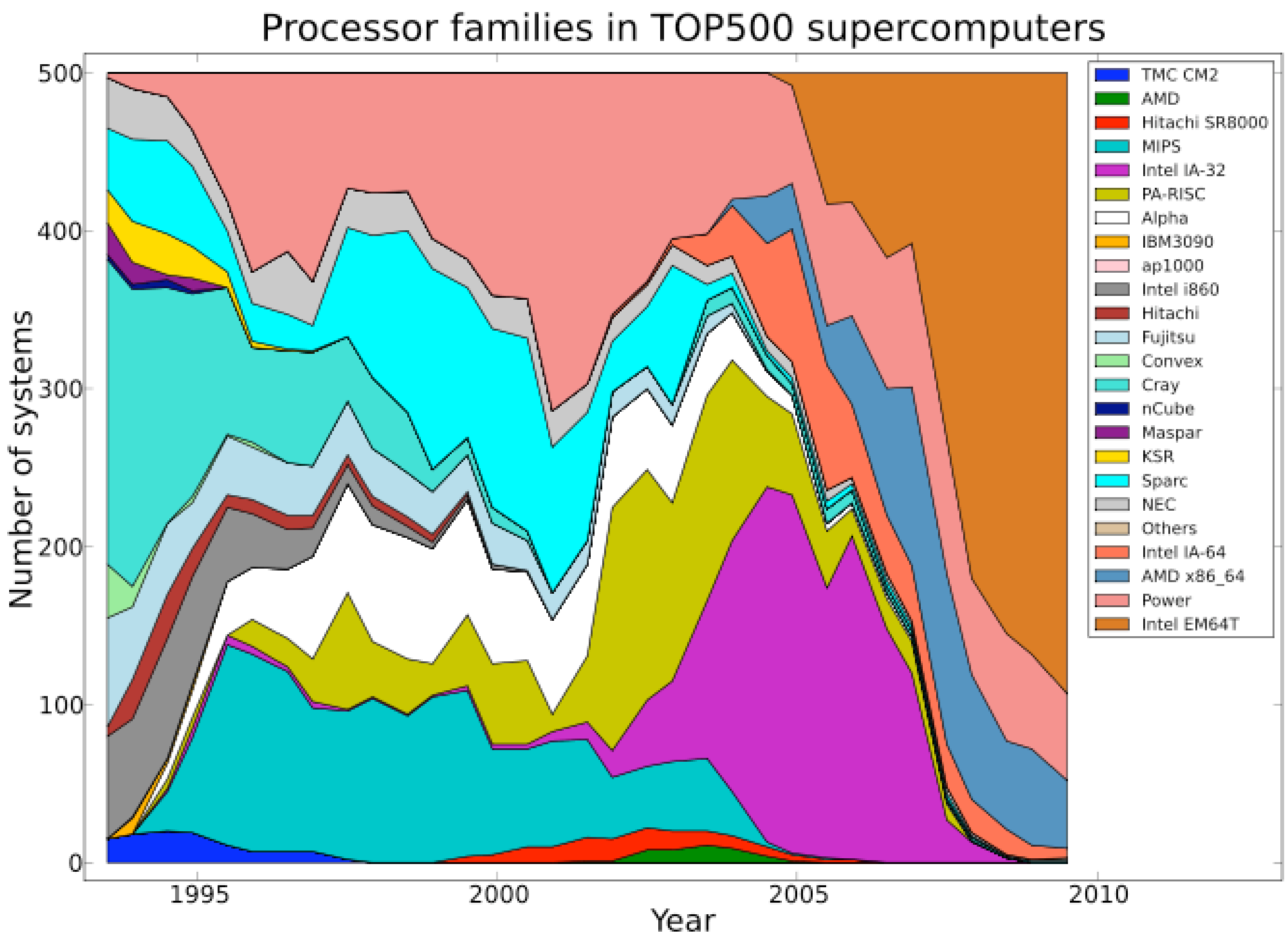
Rank	Site	System	Cores	R_{max}	R_{peak}
1	DOE/NNSA/LANL United States	BladeCenter QS22/LS21 Cluster, PowerXCell 8i 3.2 Ghz / Opteron DC 1.8 GHz, Voltaire Infiniband IBM	129600	1105	1456.7
2	Oak Ridge National Laboratory United States	Cray XT5 QC 2.3 GHz Cray Inc.	150152	1059	1381.4
3	Forschungszentrum Juelich (FZJ) Germany	Blue Gene/P Solution IBM	294912	825.5	1002.7
4	NASA/Ames Research Center/NAS United States	SGI Altix ICE 8200EX, Xeon QC 3.0/2.66 GHz SGI	51200	487.01	608.83
5	DOE/NNSA/LLNL United States	eServer Blue Gene Solution IBM	212992	478.2	596.38

Slicing the Top 500 Pie





Share vs. Time

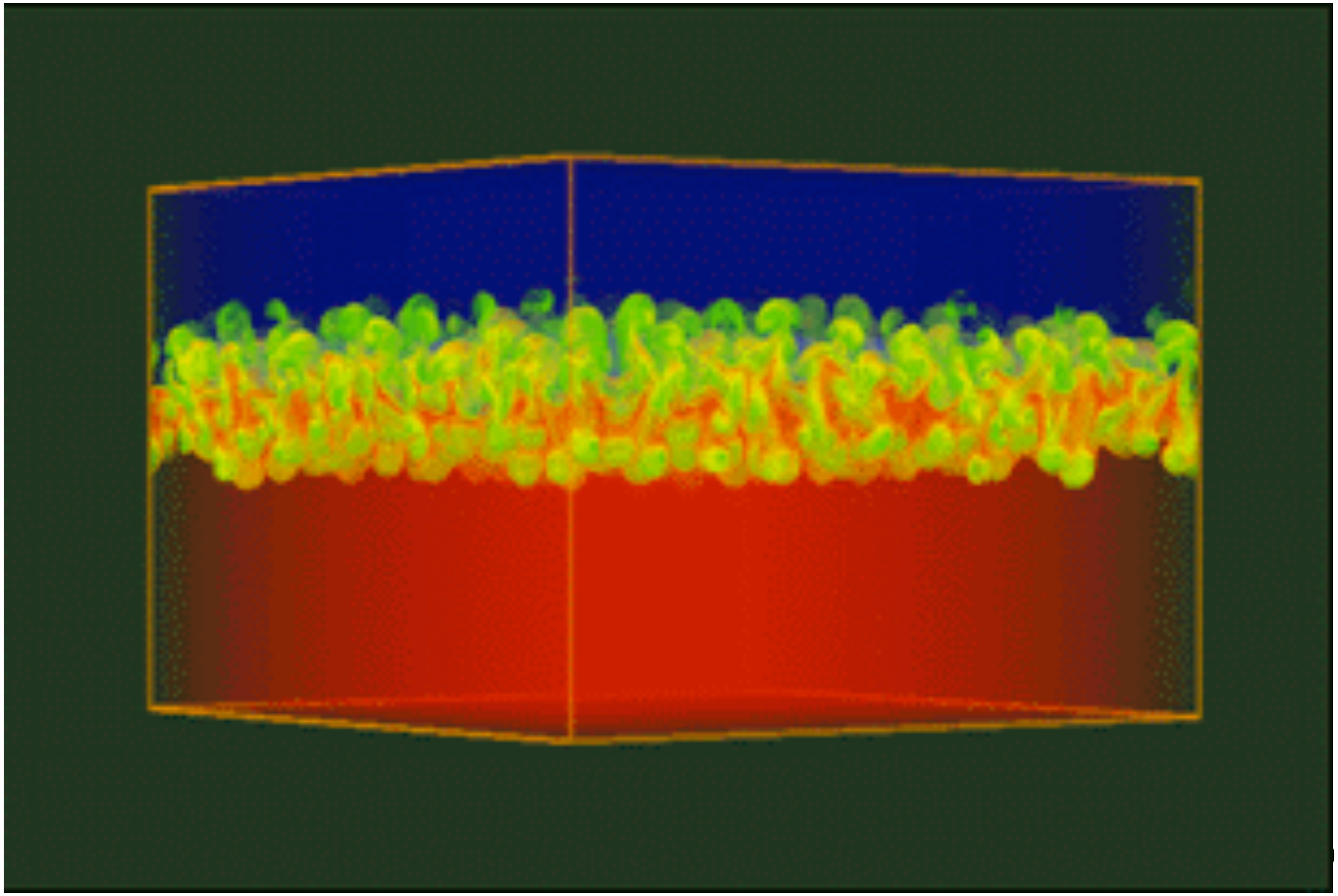


HP?

Rank	Site	System	Cores	R_{max}	R_{peak}
18	Computational Research Laboratories, TATA SONS India	Cluster Platform 3000 BL460c, Xeon 53xx 3GHz, Infiniband Hewlett-Packard	14384	132.8	172.61
30	Government Agency Sweden	Cluster Platform 3000 BL460c, Xeon 53xx 2.66GHz, Infiniband Hewlett-Packard	13728	102.8	146.43
34	Pacific Northwest National Laboratory United States	Cluster Platform 4000 DL185G5, Opteron QC 2.2 GHz, Infiniband DDR Hewlett-Packard	18176	97.07	159.95
35	IT Service Provider Germany	Cluster Platform 3000 BL2x220, E54xx 3.0 Ghz, Infiniband Hewlett-Packard	10240	94.74	122.88
54	Joint Supercomputer Center Russia	Cluster Platform 3000 BL460c/BL2x220, Xeon 54xx 3 Ghz, Infiniband Hewlett-Packard	7920	71.28	95.04
59	University of Minnesota/Supercomputing Institute United States	Cluster Platform 3000 BL280c G6, Xeon X55xx 2.8Ghz, Infiniband Hewlett-Packard	8048	64	90.14

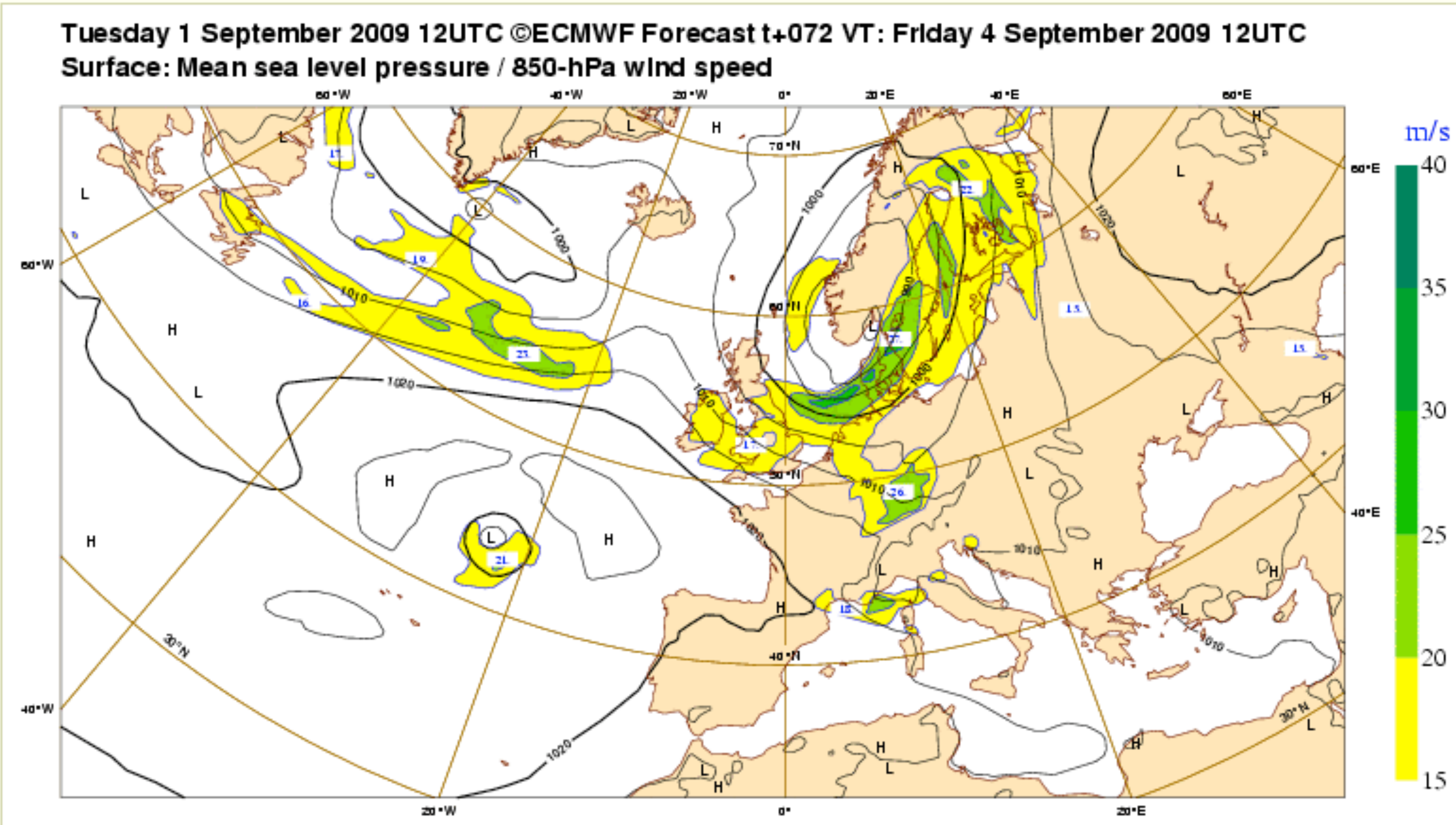
Rayleigh-Taylor Simulation (Turbulence)

http://www.llnl.gov/casc/asciturb/simulations.shtml



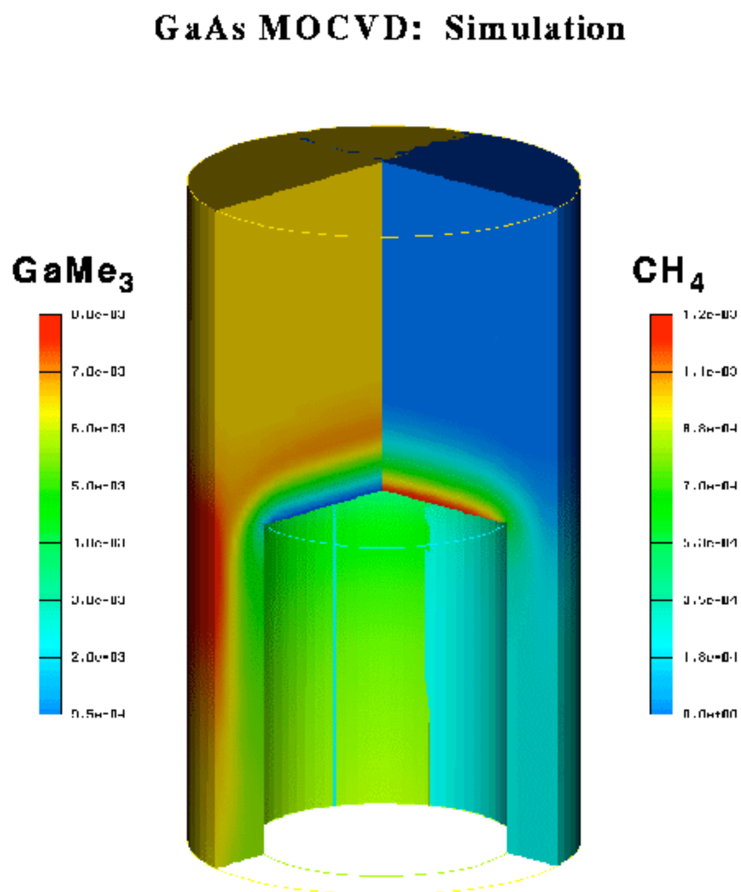
3-day Forecast, Northern Hemis.

http://www.ecmwf.int



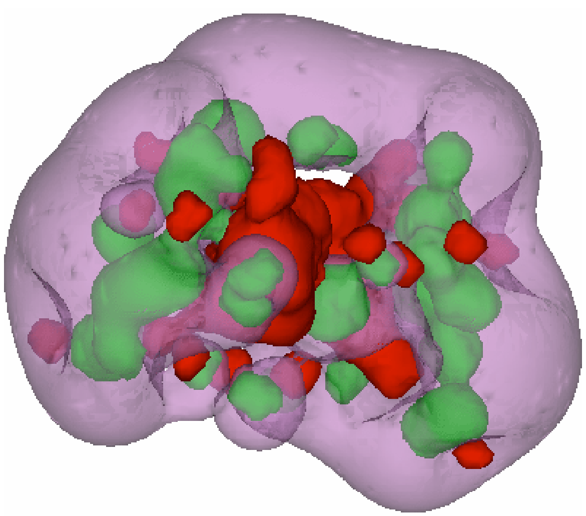
Reactor Modeling

http://www.cs.sandia.gov/CRF/MPSalsa/main_pictures.htm

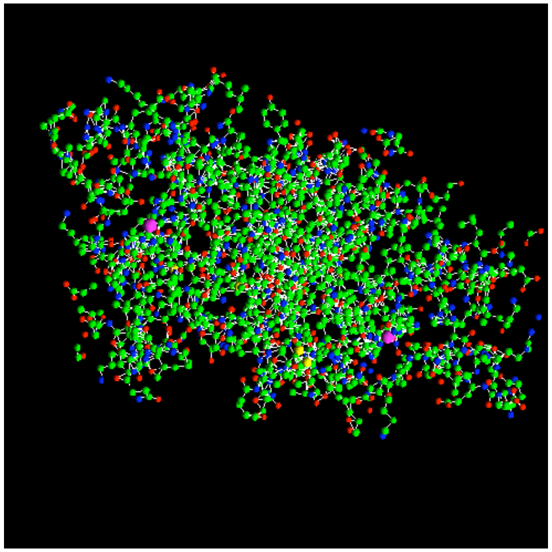


Solution of the Poission-Boltzmann equation

(from http://compbio.caltech.edu/applications/pmg/sod.html)



Isosurfaces of electrostatic potentials in the SOD (SuperOxide Dismutase) enzyme obtained by solving the nonlinear Poisson-Boltzmann equation numerically. The SOD enzyme is an antiradical or antioxident, meaning that it moves around the body binding to and then deactivating free radicals in the body, preventing them from causing cancer or other cell damage in the body.



SOD enzyme molecular structure