

# System Operation of the Earth Simulator (ES2)

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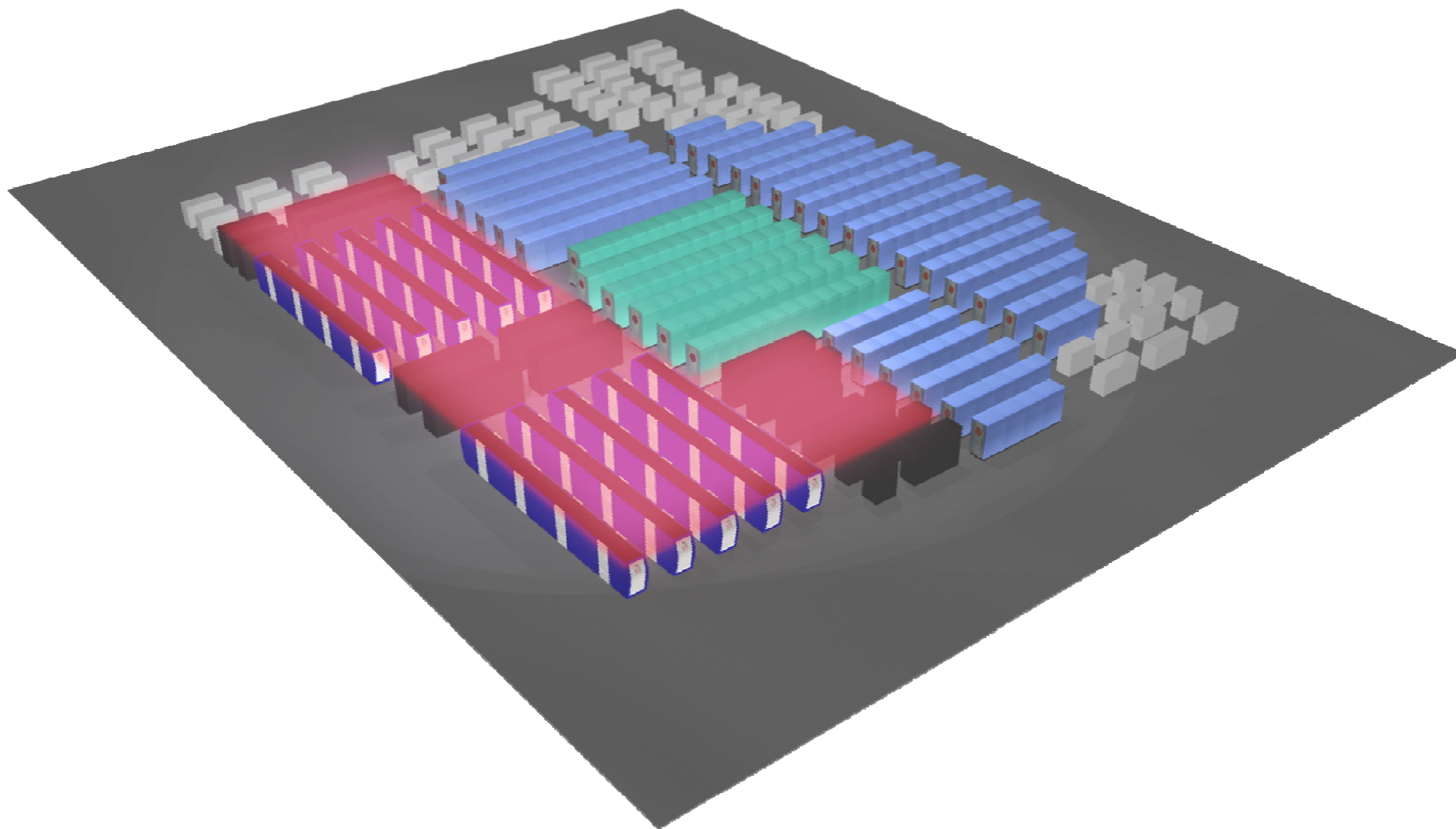
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# Earth Simulator (ES2)

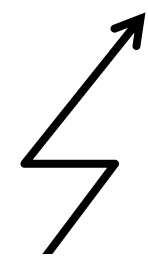


# ES2 installation space

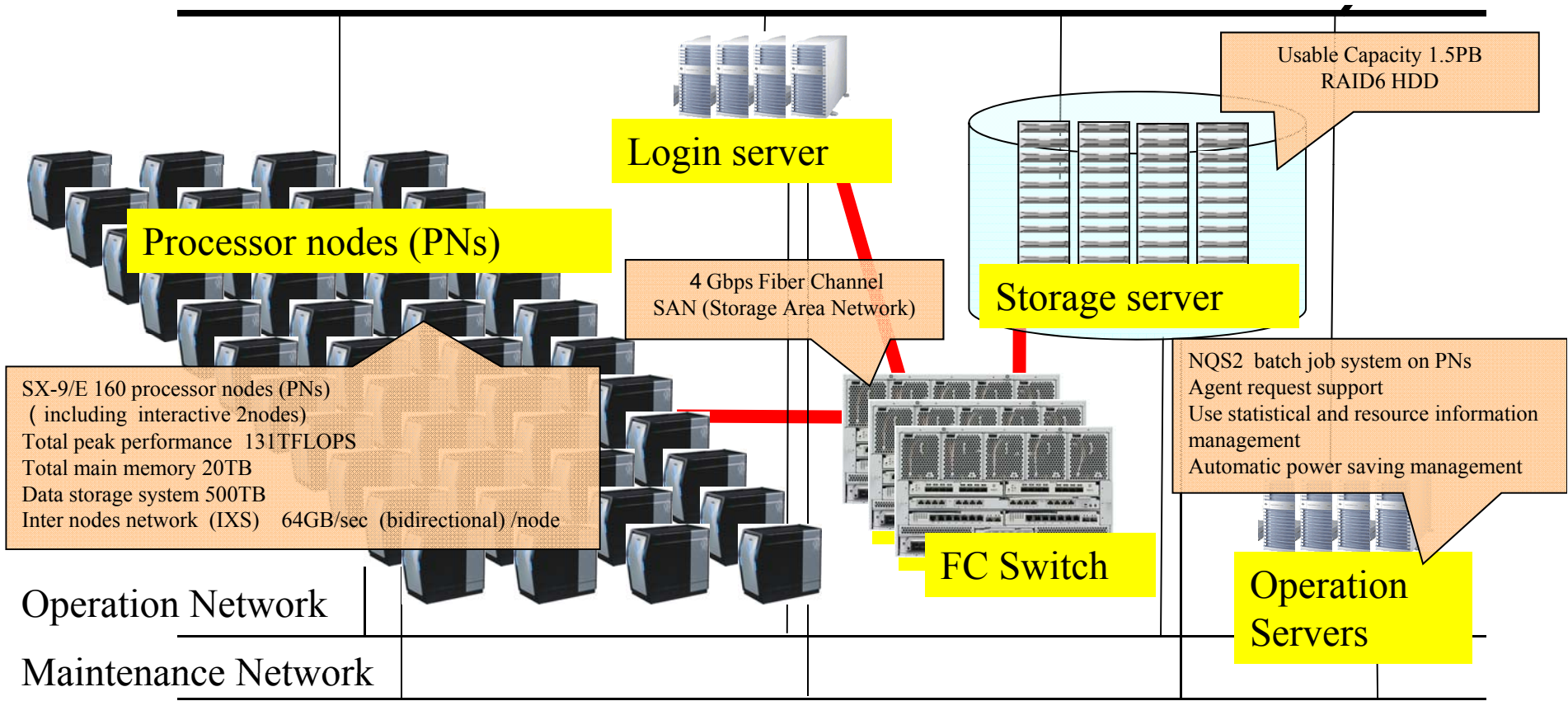


# ES2 System outline

10GbE  
(partially link aggregation 40GbE)



User Network



SX-9/E 160 processor nodes (PNs)  
( including interactive 2nodes)  
Total peak performance 131TFLOPS  
Total main memory 20TB  
Data storage system 500TB  
Inter nodes network (IXS) 64GB/sec (bidirectional)/node

Operation Network

Maintenance Network



# Features of the Earth Simulator (ES2) important for operation and control

- Clustering of nodes to control the system (transparent for users) .  
A cluster consists of 32 nodes.  
156 nodes are for batch jobs (batch clusters).
- Providing special 4 nodes for TSS and small batch jobs.
- Configuration of the TSS cluster.
  - TSS nodes [2 nodes → 1node (changed in 2010)]
  - Nodes for Single Node batch jobs [2 nodes → 3 nodes ] ,
- Configuration of the batch cluster.
  - Nodes for Multi-Nodes batch jobs,
  - System disks for user-file staging,
- Storage of user files for batch jobs on a mass-storage system.  
Automated file recall (Stage-In) and migration (Stage-Out).  
Connection of all the clusters to a mass-storage system by IOCS (Linux WS)

# Hardware Spec.

		ES	ES2 (SX-9/E)	Ratio
CPU	Clock Cycle	1GHz	3.2GHz	3.2x
	Performance	8GF	102.4GF	12.8x
Node	# CPUs	8	<u>8</u>	1x
	Performance	64GF	819.2GF	12.8x
	Memory	16GB	<u>128GB</u>	8x
	Network	12.3GB/s x2	8GB/s x8 x2	5.2x
System	# Nodes	640	<u>160</u>	1/4x
	Performance	40TF	131TF	3.2x
	Memory	10TB	20TB	2x
	Network	Full Crossbar	<u>2Lvel Fat Tree</u> <u>Full Bisection</u> <u>Bandwidth</u>	-



# Projects

## FY2010 ES2 Projects

- **Proposed Research Projects : 31**

**Earth Science :19 Innovation : 21**

- **Contract Research Projects**

- **KAKUSHIN 5**

- **The Strategic Industrial Use (Industrial) 13**

- **CREST 3**

- **JAMSTEC Research Projects 14**

- **JAMSTEC**

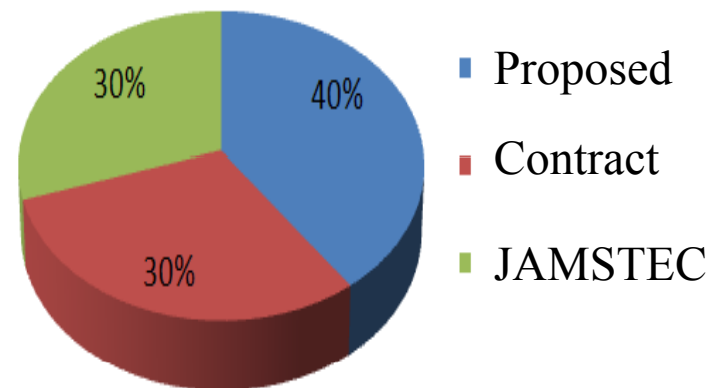
- **Collaboration Research**

- **Industrial fee-based usage ( New project is accepted at any time.)**

**Users : 593**

**Organization 122**

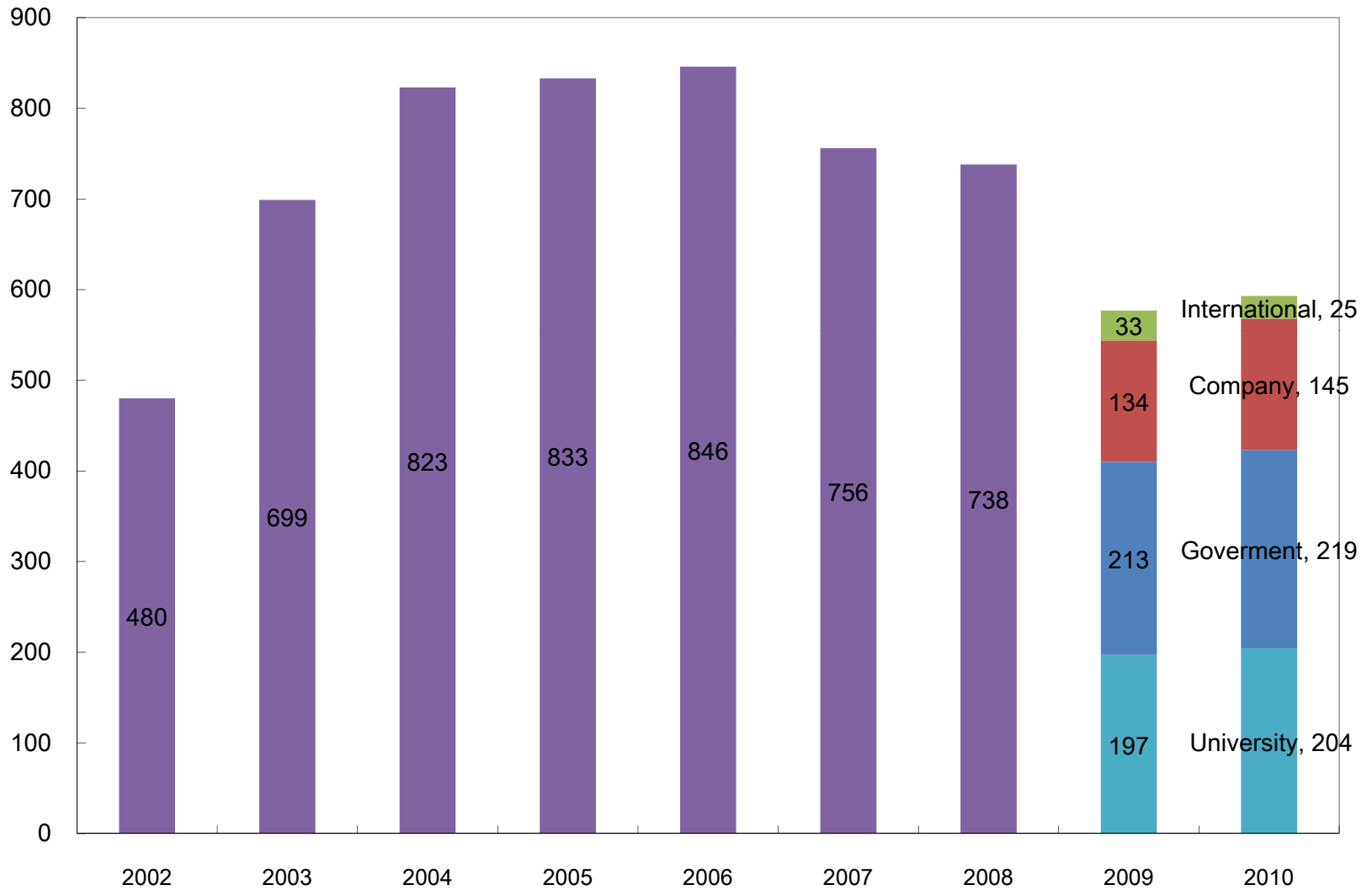
**University 55, Government 13, Company 36, International 18**



Resource Allocation



# ES Users ( FY2002 ~ FY2010 )

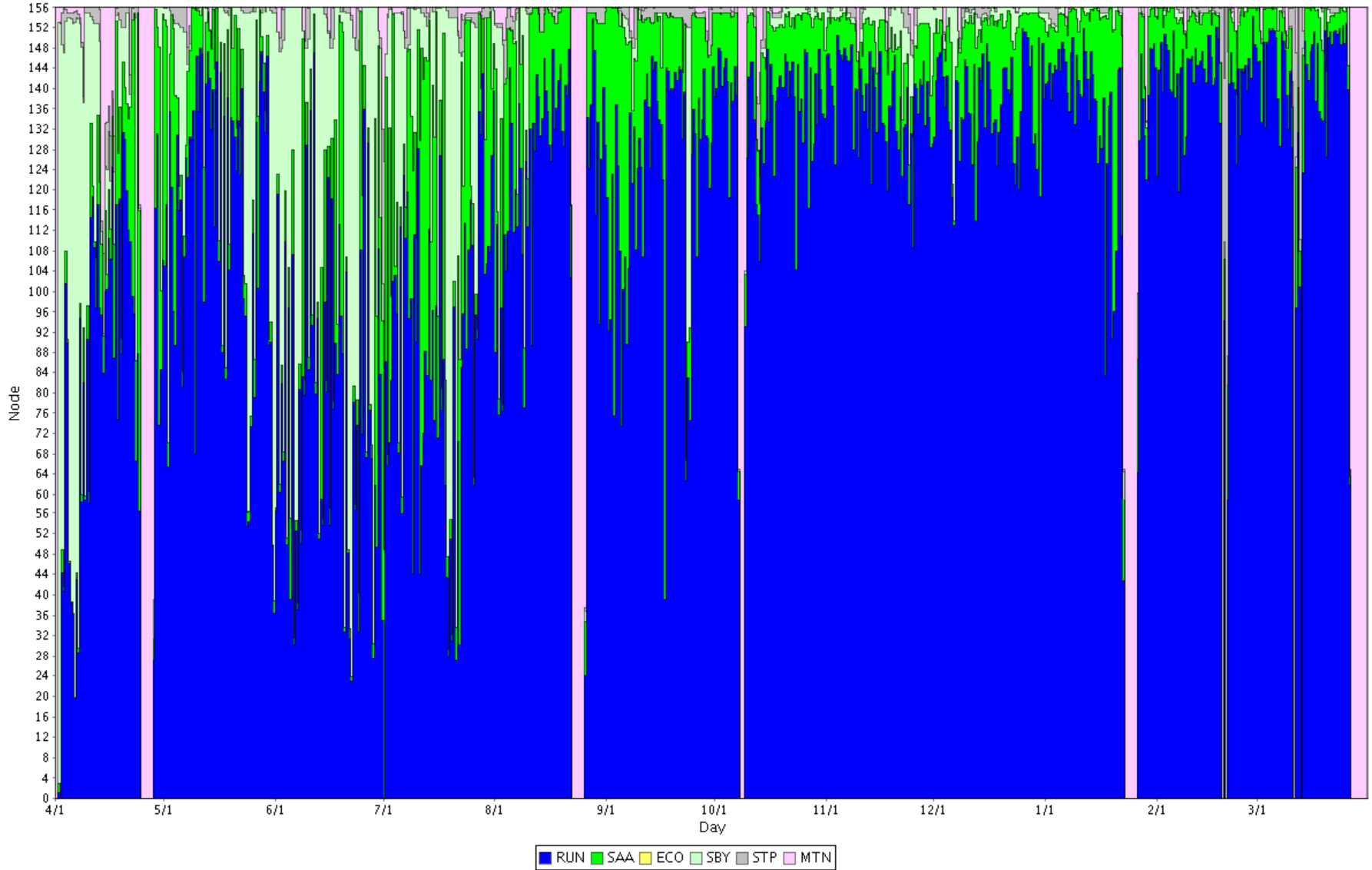






### Node usage in fiscal 2009

RUN: 72.19 % SAA: 10.35 % ECO: 0.00 % SBY: 9.84 % STP: 1.52 % MTN: 6.10 %

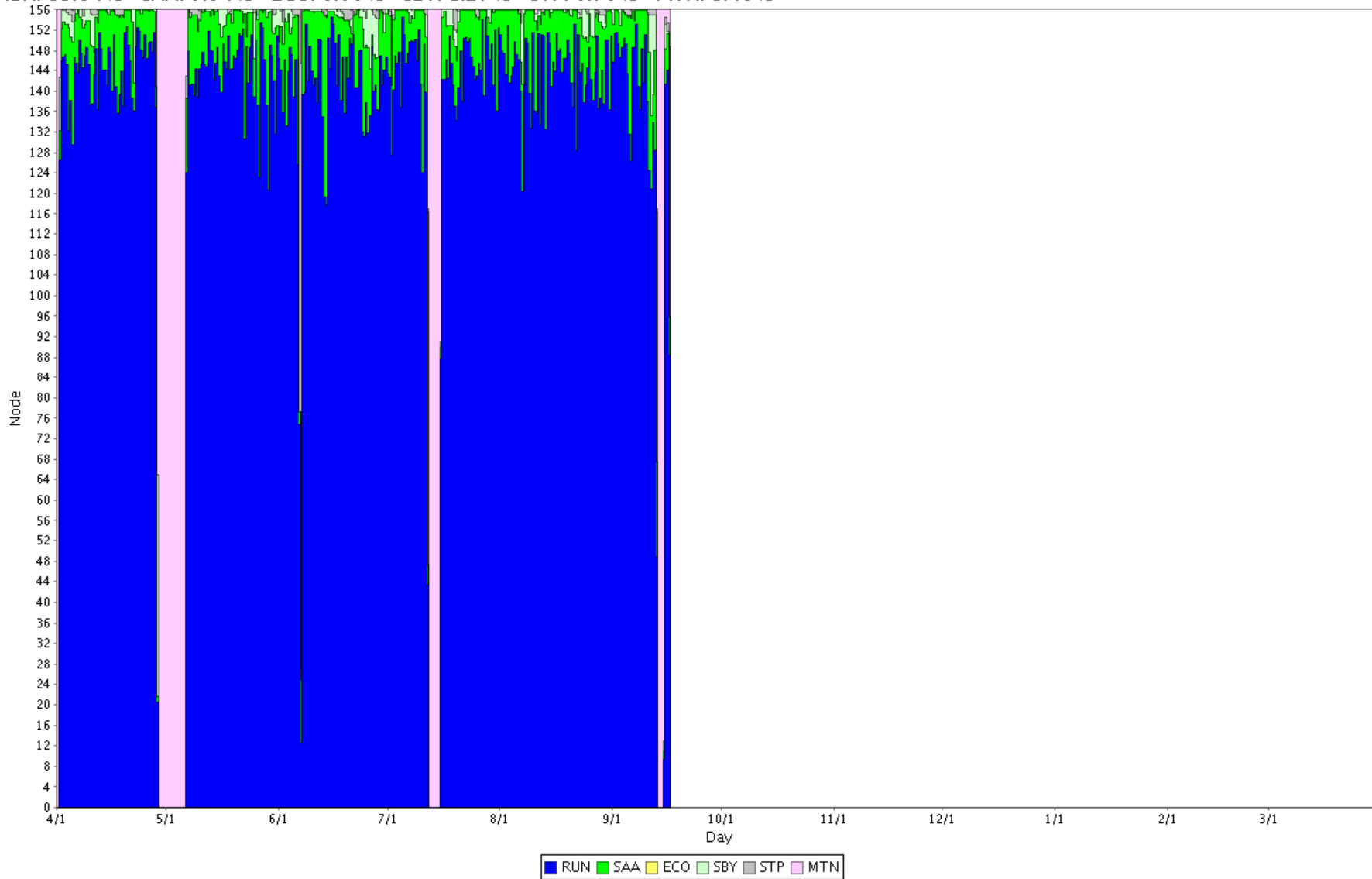




EART  
SIMUI

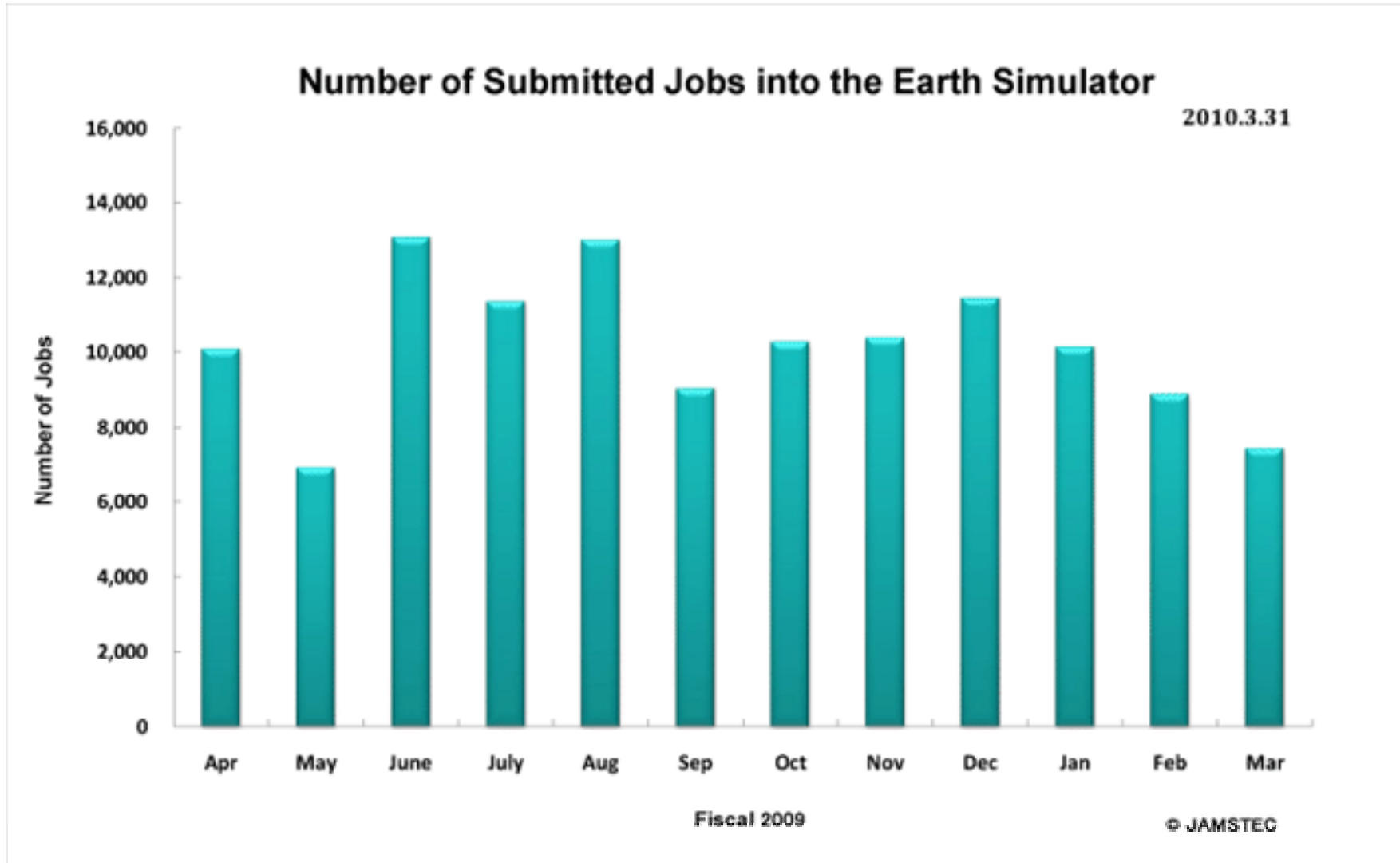
### Node usage in fiscal 2010

RUN: 83.64 % SAA: 5.94 % ECO: 0.00 % SBY: 1.27 % STP: 0.70 % MTN: 8.46 %



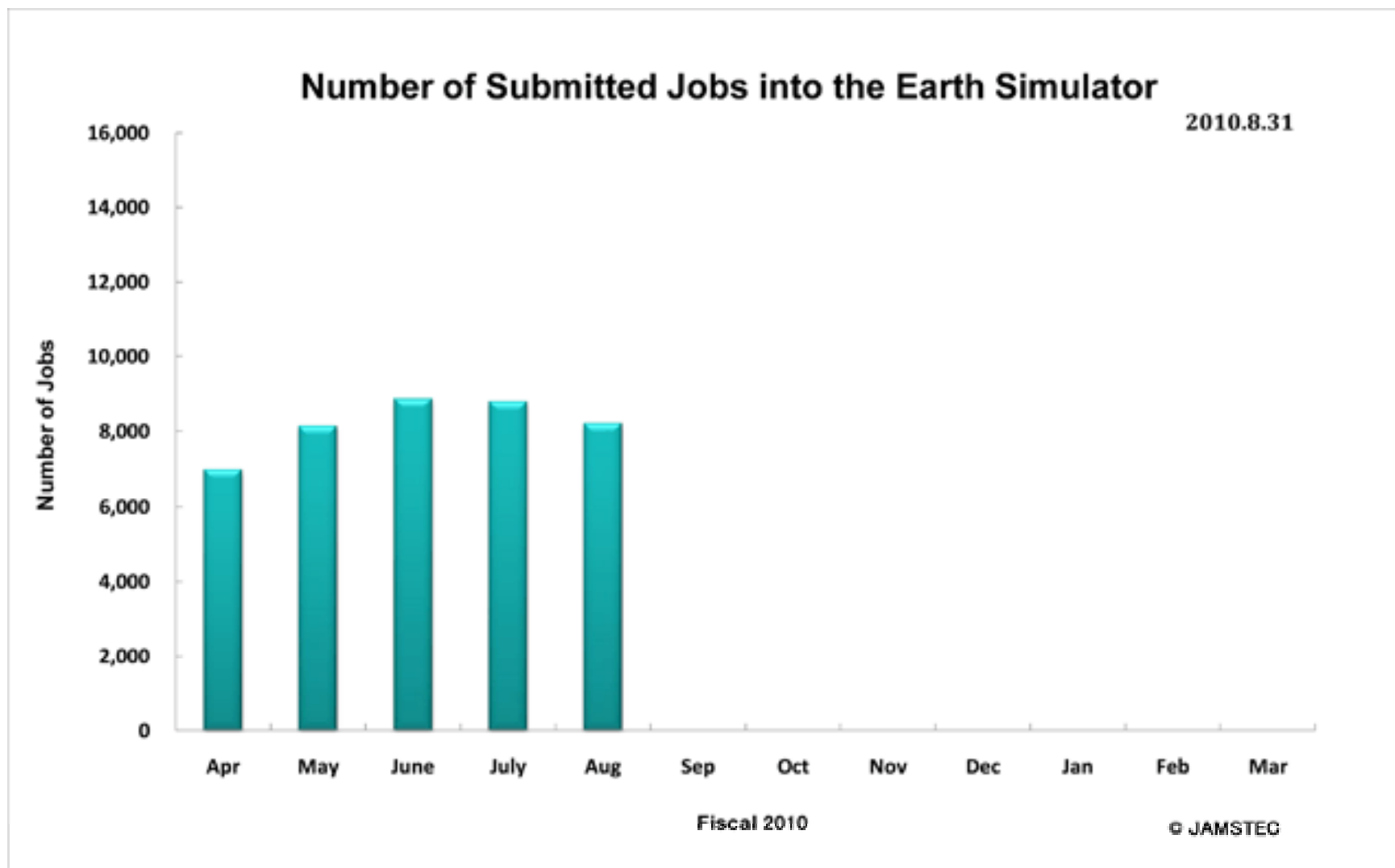


# #of User Jobs ( FY2009 )



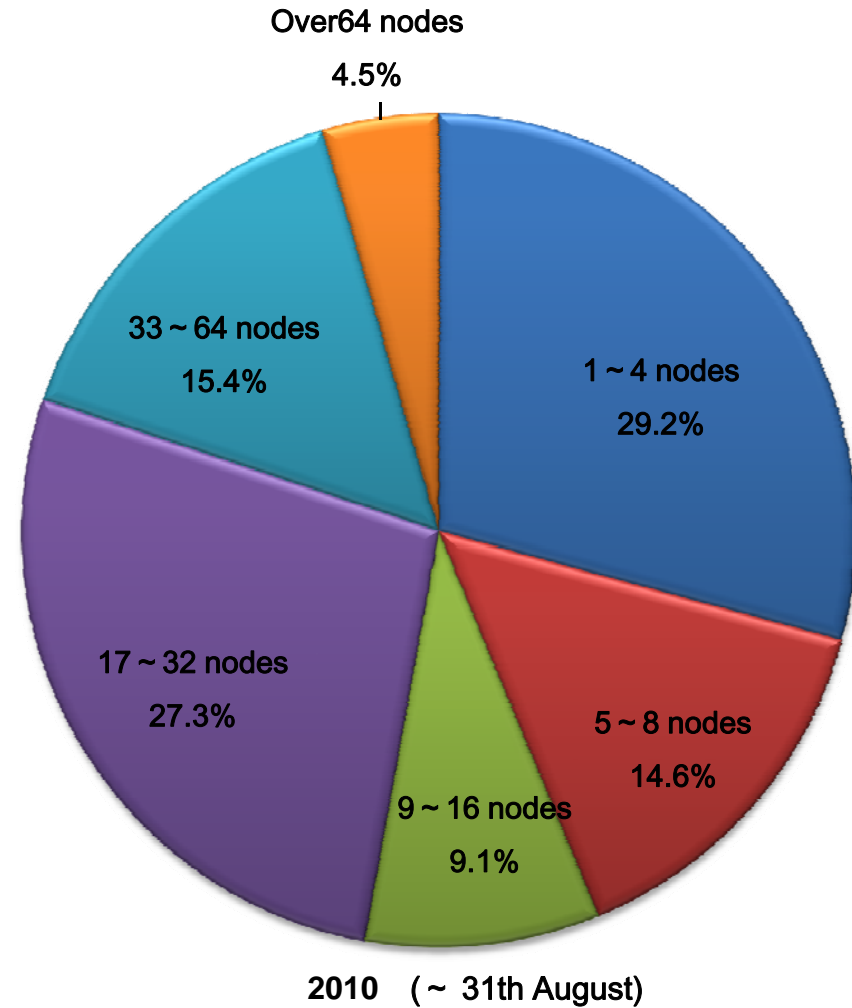
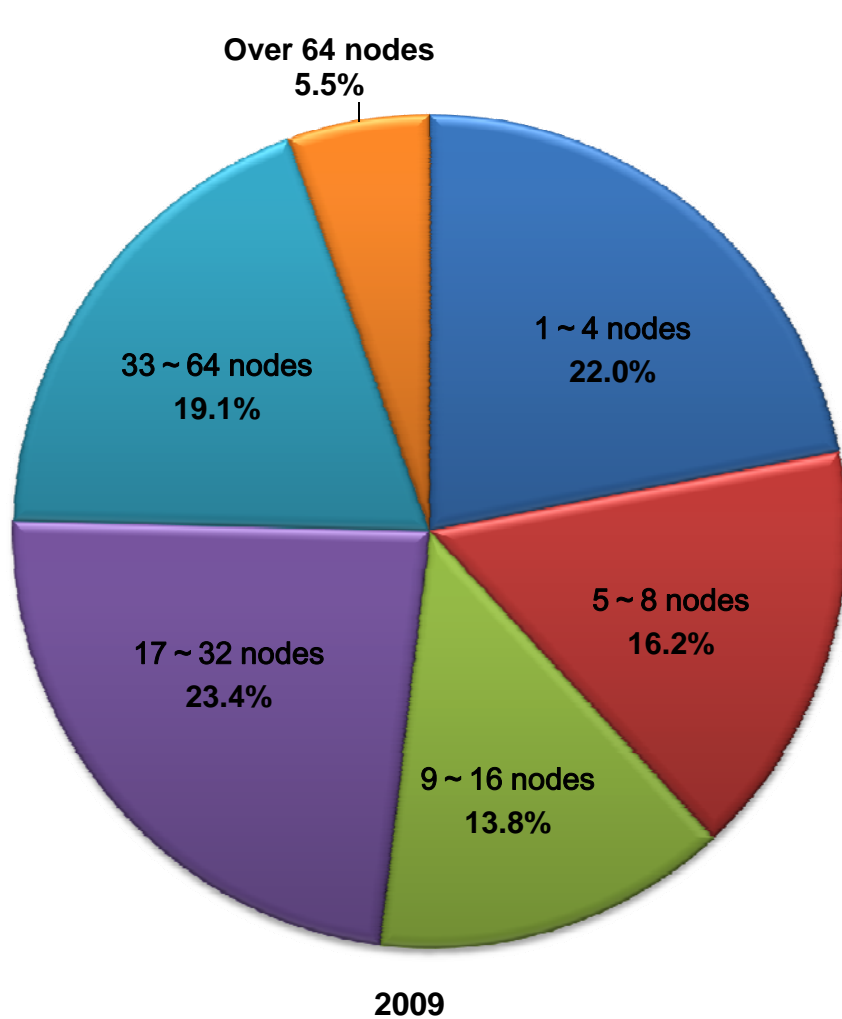


# #of User Jobs ( FY2010 )





# Computing Resource Distribution Based on Job Resource Size (#nodes \* Time)

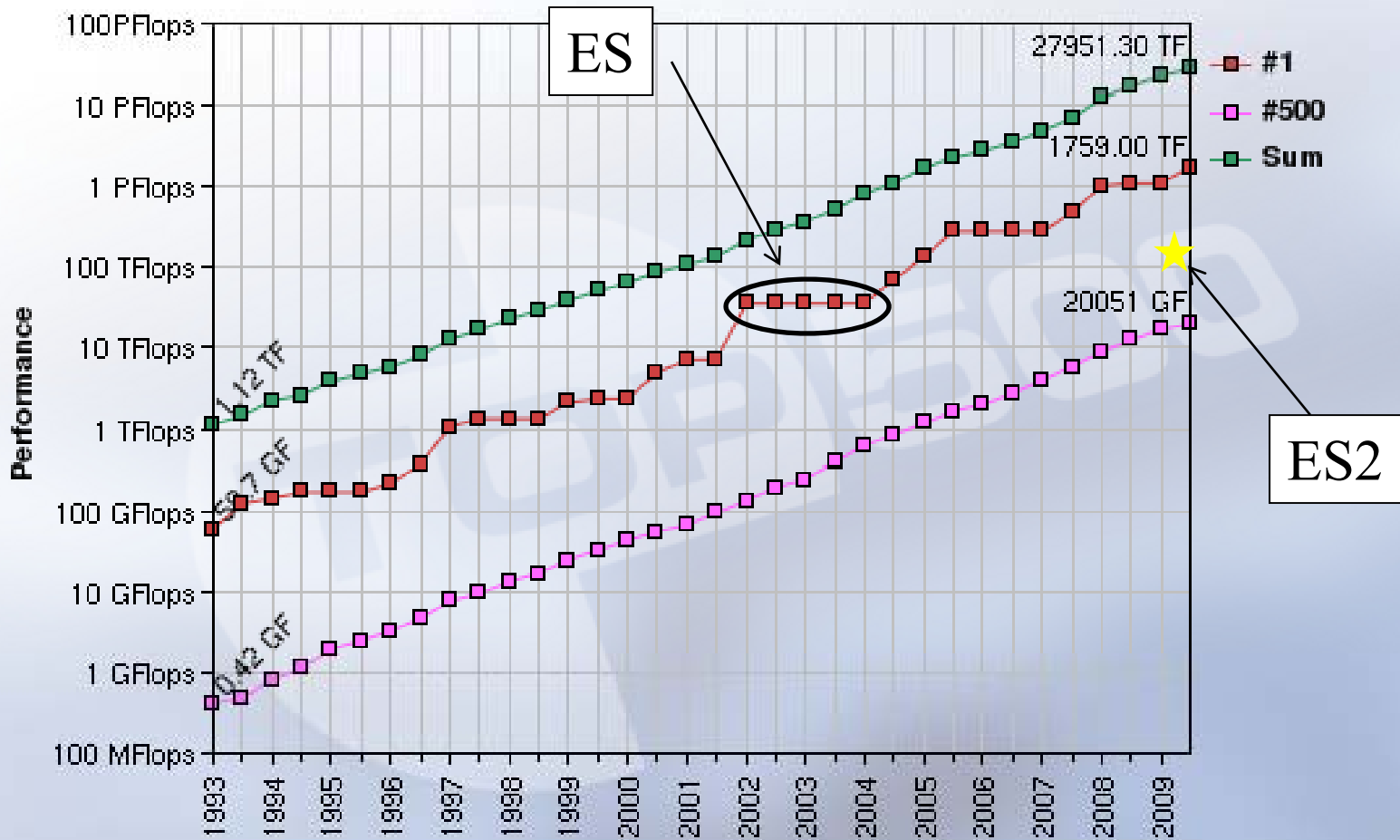


## Performance Evaluation Results In ES Real Applications

Code Name	Elapse Time on ES [sec]	#CPUs on ES	Elapse Time on ES2 [sec] (Speedup ratio)	#CPUs on ES2
PHASE	135.3	4096	62.2 (2.18)	1024
NICAM-K*	214.7	2560	109.3 (1.97)	640
MSSG	173.9	4096	86.5 (2.01)	1024
SpecFEM3D	96.3	4056	45.5 (2.12)	1014
Seism3D	48.8	4096	15.6 (3.13)	1024
Speedup ratio harmonic mean			2.22	

**ES2 is 2.22 times faster**

# Performance Development



13/11/2009

<http://www.top500.org/>



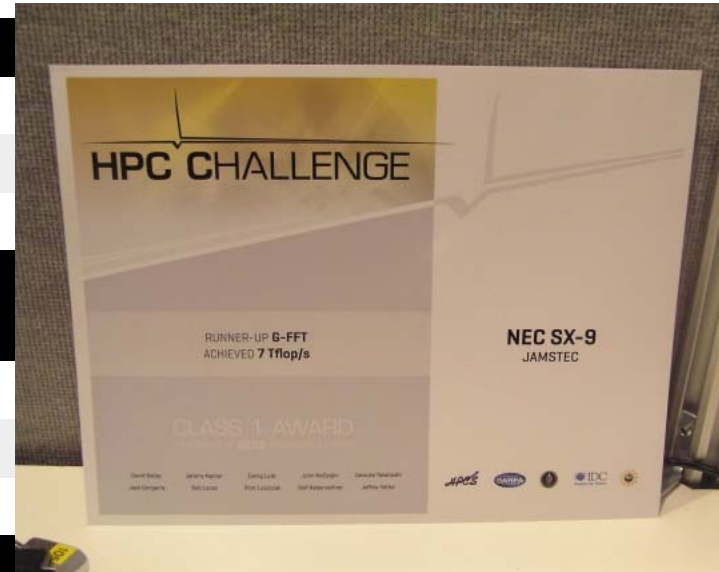
# The 2009 HPC Challenge Class 1 Awards:

G-HPL	Achieved	System	Affiliation
1st place	2.3 PF	Cray XT5	ORNL
1st runner up	131 TF	ES2	ORNL

XT5@ORNL is 2.3PF and ES2 is 131TF at peak. That is about 17 times . However, G-FFT performance is only 1.5 times.

G-FFT	Achieved	System	Affiliation
1st place	11 Tflop/s	Cray XT5	ORNL
1st runner up	8 Tflop/s	Cray XT5	UTK
2nd runner up	7 Tflop/s	NEC SX-9	JAMSTEC

EP-STREAM-Triad (system)	Achieved	System	Affiliation
1st place	398 TB/s	Cray XT5	ORNL
1st runner up	267 TB/s	IBM BG/P	LLNL
2nd runner up	173 TB/s	NEC SX-9	JAMSTEC





## ES vs.. ES 2 Power Consumption (including utility, cooling system)

	April	May	June	July	August	Sep.	Oct.
<b>ES2</b> 2009 (KWH)	3,065	3,105	2,944	3,084	2,973	3,042	3,091
<b>ES</b> 2008 (KWH)	3,987	4,013	3,978	4,015	4,138	3,986	1,752 (half System)
<b>Reduction rate</b>	76.9%	77.4%	74.0%	76.8%	71.9%	76.3%	(176.5 %)

- ES2 power consumption is reduced about 75% from ES.
- The ratio of peak performance and power consumption is 4.34 times better than ES.

# Summary

- The Earth Simulator (ES2) began operation in March, 2009.
- 2.22 times the speed up were achieved in the bench mark that had been evaluated when introducing.
- 122.4TFLOPS was achieved in the LINPACK bench mark, and the 31<sup>st</sup> place. It is the top class in the execution efficiency (93.39%).
- HPC Challenge Benchmark Class 1 Awards  
the 3<sup>rd</sup> G-FFTE 7TFLOPS (120nodes)  
the 3<sup>rd</sup> EP-STREAM-Triad 173GB/sec (120nodes)
- ES2 power consumption is reduced about 75% from ES.