# Jaguar – The world's most powerful computer

Presented by

**Buddy Bland**

Leadership Computing Facility Project Director
National Center for Computational Sciences

# Jaguar: World's most powerful computer—Designed for science from the ground up

| | |
|---|---|
| **Peak performance** | **1.645 PF** |
| System memory | 362 TB |
| Disk space | 10.7 PB |
| Disk bandwidth | 240+ GB/s |
| Interconnect bandwidth | 532 TB/s |

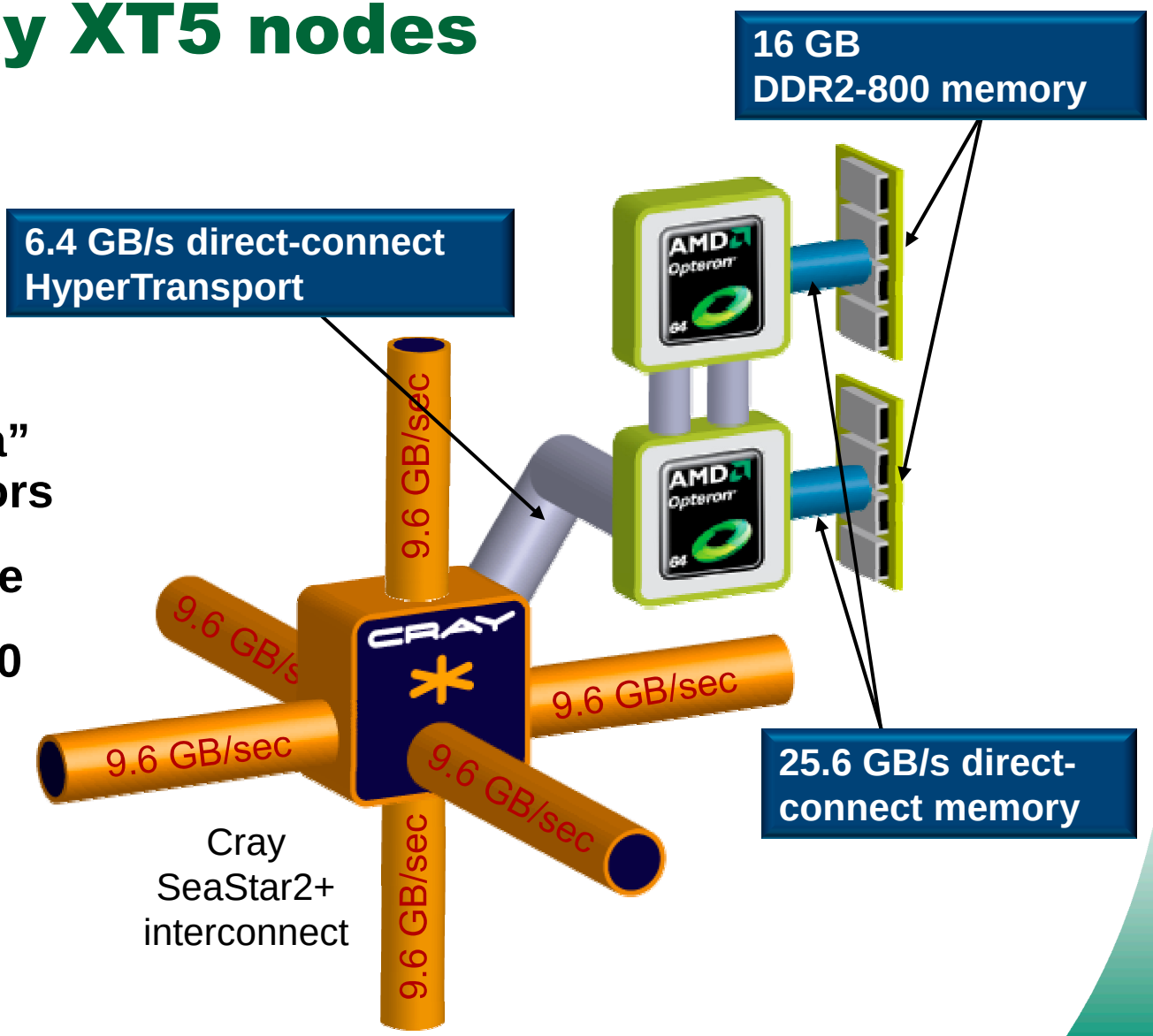
# What does the system look like?

## Jaguar combines the existing 263 TF Cray XT4 system at ORNL's NCCS with a new 1,382 TF Cray XT5 to create a 1.64 PF system

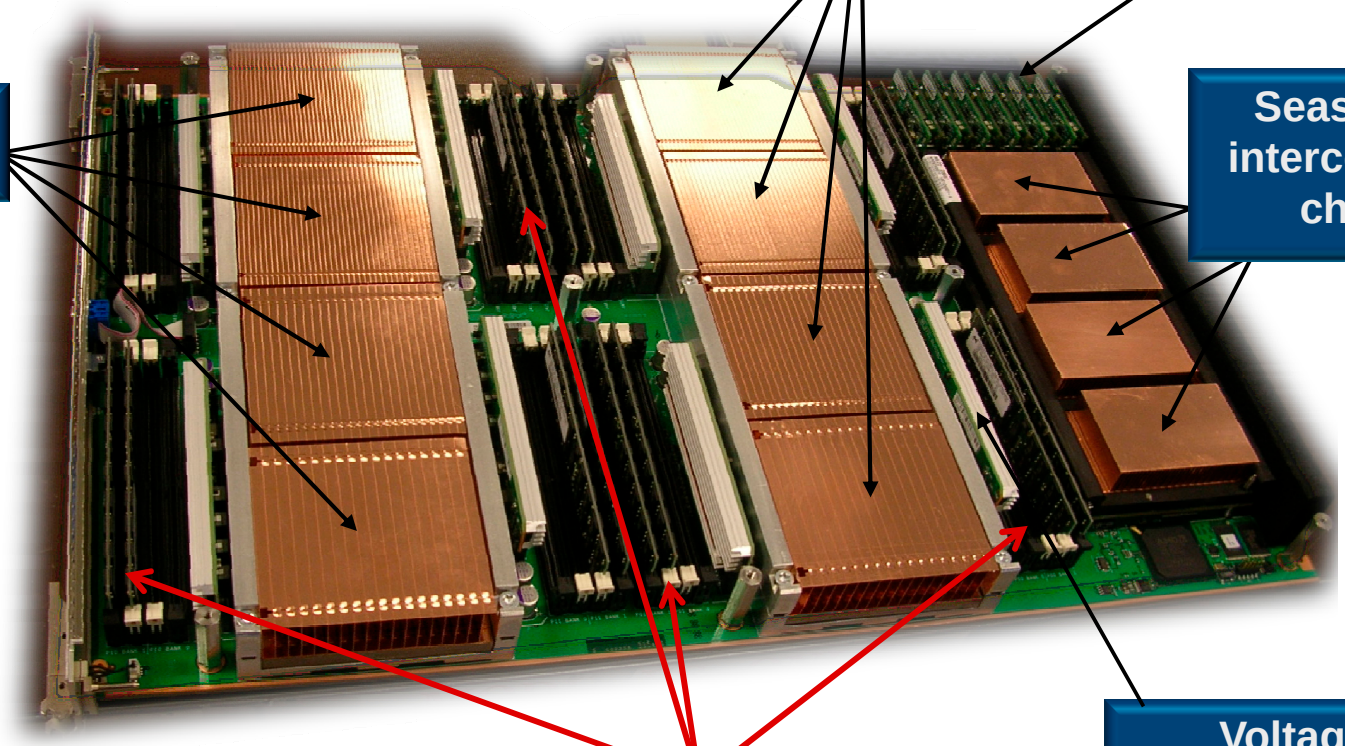
| System attribute | XT5 | XT4 |
|---|---|---|
| Quad-core AMD Opteron processors | 37,544 | 7,832 |
| Node architecture | Dual socket SMP | Single Socket |
| Memory per core/node (GB) | 2/16 | 2/8 |
| Total system memory (TB) | 300 | 62 |
| Disk capacity (TB) | 10,000 | 750 |
| Disk bandwidth (GB/s) | 240 | 44 |
| Interconnect | SeaStar2+<br>3D torus | SeaStar2+<br>3D torus |

# Jaguar's Cray XT5 nodes

- Eight-core SMP
- Two 2.3 GHz AMD Opteron "Barcelona" quad-core processors
- 73.6 Gflops per node
- Four 4 GB DDR2-800 DIMMS with four empty DIMM slots per node
- OpenMP Support



# Jaguar's Cray XT5 blades




- 4 nodes per blade
- 294.4 GF
- 64 GB
- 4 network connections

# 24 Cray XT5 blades make a Jaguar cabinet

One Jaguar XT5 cabinet:

- 7 TF
- 192 Opteron processors
- 776 Opteron cores
- 1,536 GB memory
- 96 nodes
- 1•4•24 section of 3D torus

# 200 cabinets complete the XT5 side of the system

**Compute partition**

- Nodes: 18,772
- Opteron processors: 37,544
- Processor cores: 150,176
- Peak TF: 1.38
- Memory: 300 TB
- Interconnect: 25•32•24 3D torus

**Service and I/O partition**

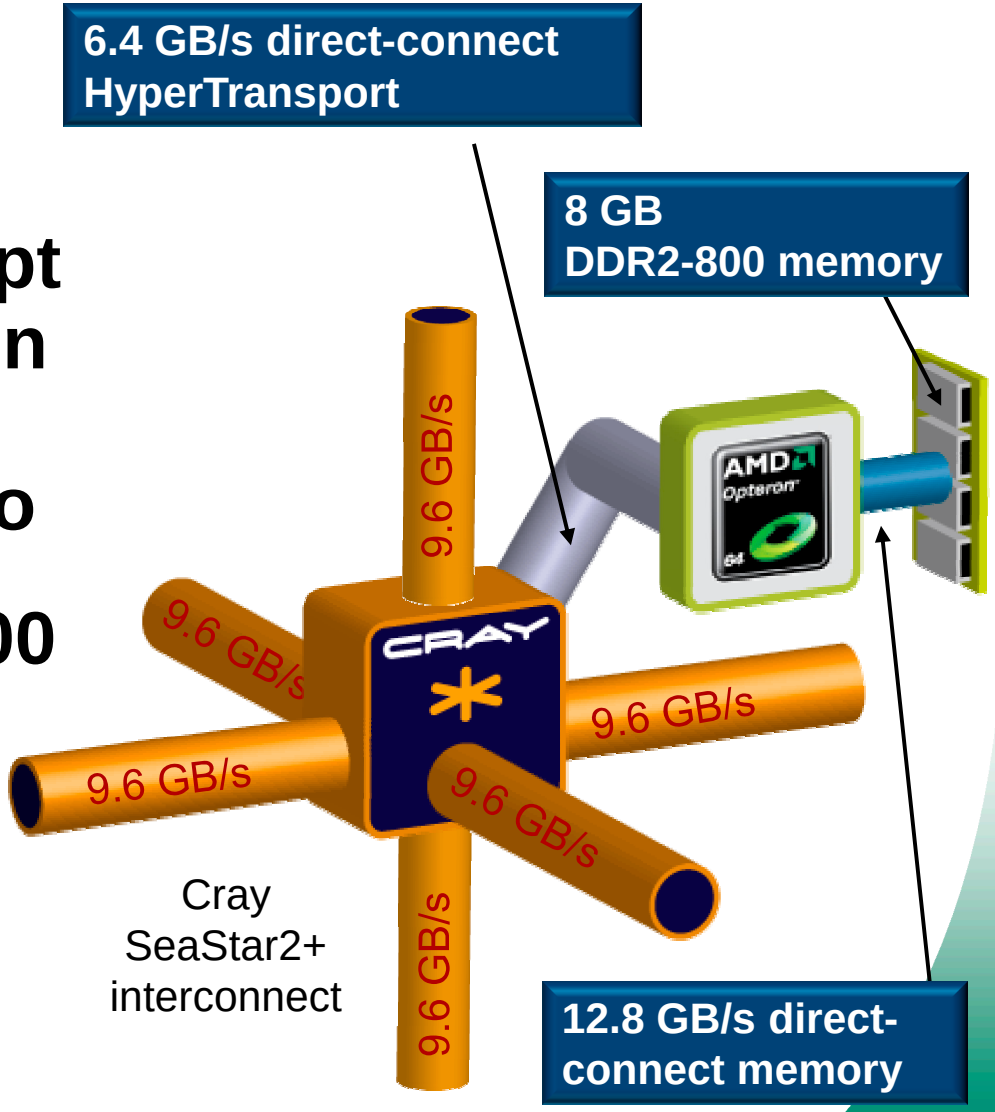
- Nodes: 214
- InfiniBand cards: 192 DDR
- Memory per SIO node: 8 GB
- 10 Gigabit Ethernet: 10

**Power and cooling**

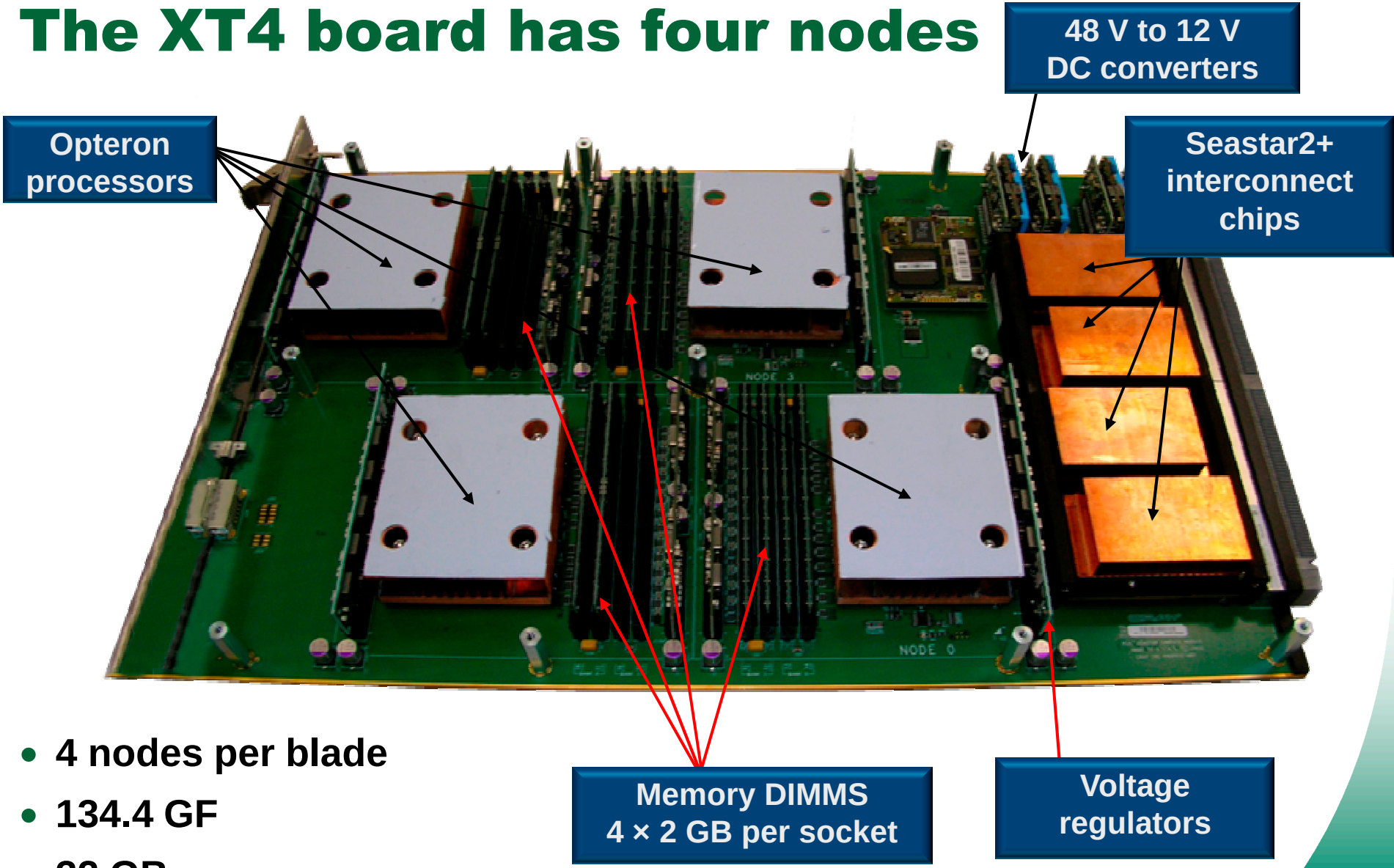
- 480 V power supplies
- R134a refrigerant
- Single large fan per cabinet

# How is the XT4 side different?

- Basic node design is the same as XT5, except it has one AMD Opteron quad-core processor per node instead of two
- Same 2 GB of DDR2-800 memory per core
- Same Seastar2+ interconnect

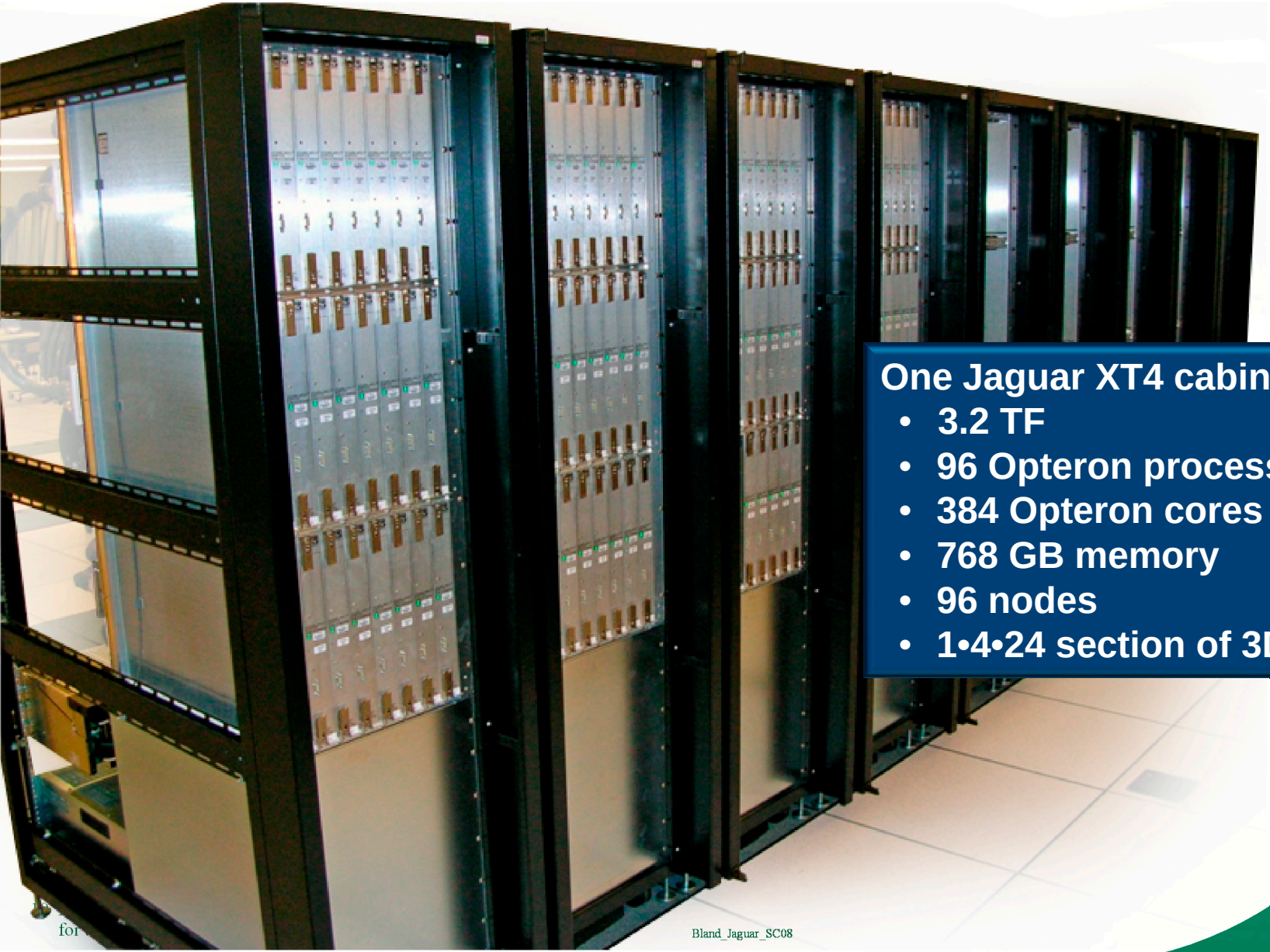


# The XT4 board has four nodes




- 4 nodes per blade
- 134.4 GF
- 32 GB
- 4 network connections

# And 24 Cray XT4 blades make a Jaguar cabinet

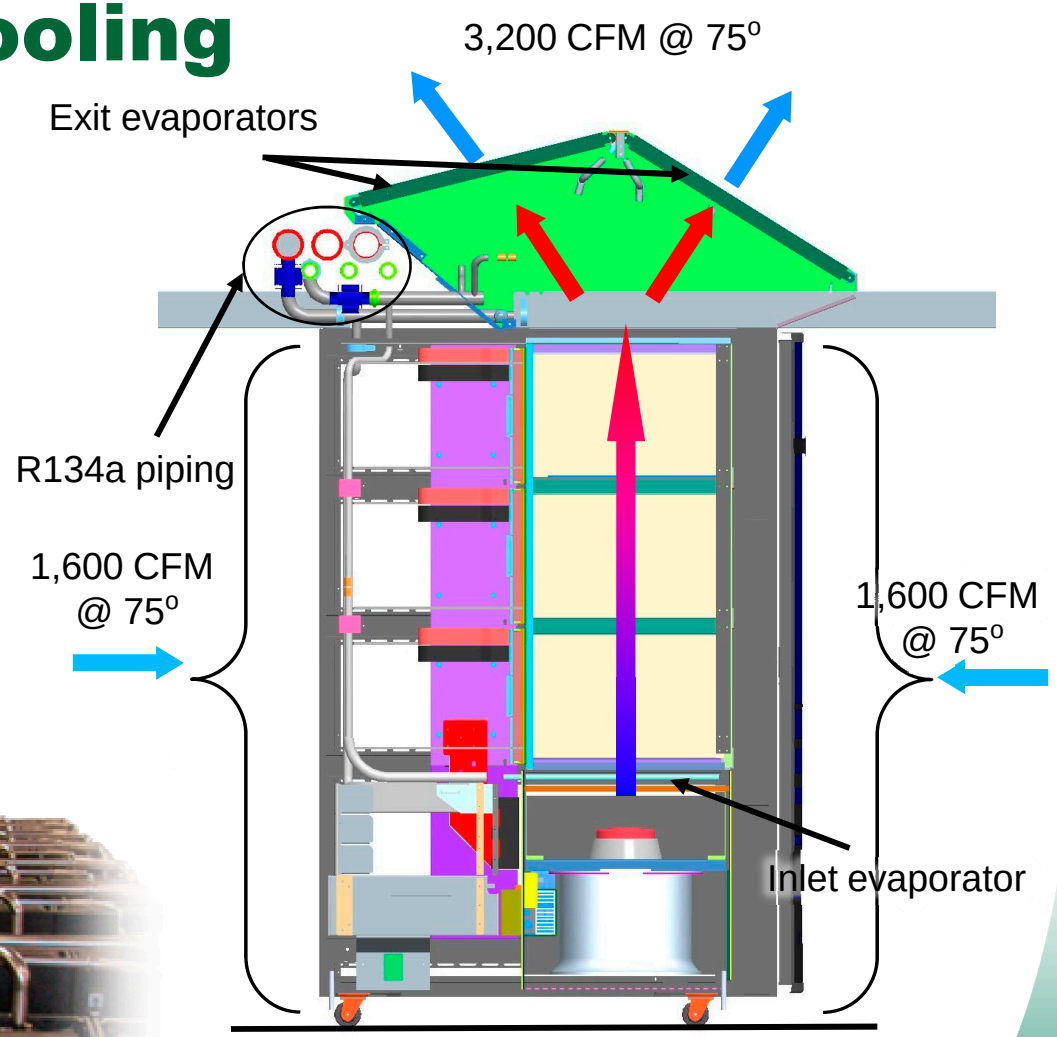


**One Jaguar XT4 cabinet:**

- 3.2 TF
- 96 Opteron processors
- 384 Opteron cores
- 768 GB memory
- 96 nodes
- 1•4•24 section of 3D torus

# ECOphlex liquid cooling

- **Liquid-cooled design exhausts heat to R134a before it leaves the cabinet. Replaces 100 CRAC units!**
- **Saves about 900 KW of power in air movement alone**

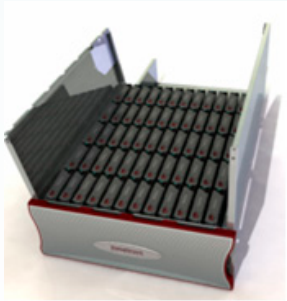


- **Phase change of liquid to gas removes heat much more efficiently**

# 480 V power saves money

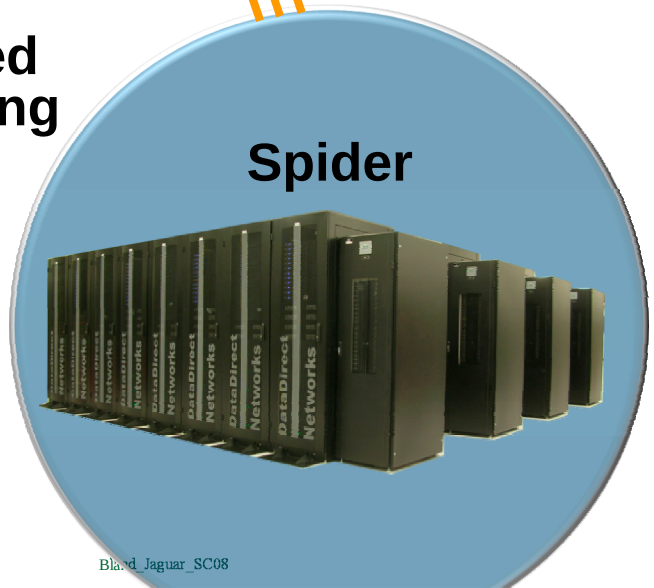
- Power supply efficiency
  - Worked with Cray to select highest-efficiency power supplies
- 480 V power to the cabinet saves the inefficiency of converting from 480 V to 208 V to 48 V
- Keeping the voltage high saved $1M in installation and $500K in electrical costs

# Centerwide file system



- "Spider" is being installed to provide a shared, parallel file system for all systems
  - Based on Lustre file system
- Bandwidth of more than 240 GB/s
- More than 10 PB of RAID6 Capacity
  - 13,440 1 TB SATA drives
- 192 storage servers
  - 3 TB of memory
  - 14 TF
- Available from all systems via our high-performance scalable I/O network
  - More than 3,000 InfiniBand ports
  - More than 3 miles of cables
  - Scales as storage grows
- Engineered for high availability

# Jaguar combines a new 1.38 PF Cray XT5 with the existing 263 TF Cray XT4




**System components are linked by 4×-DDR InfiniBand (IB) using three Cisco 7024D switches**

- **XT5 has 192 IB links**
- **XT4 has 48 IB links**
- **Spider has 192 IB links**

# Contact

**Arthur S. (Buddy) Bland**

**Leadership Computing Facility Project Director**
**National Center for Computational Sciences**
**(865) 576-6727**
**blandas@ornl.gov**