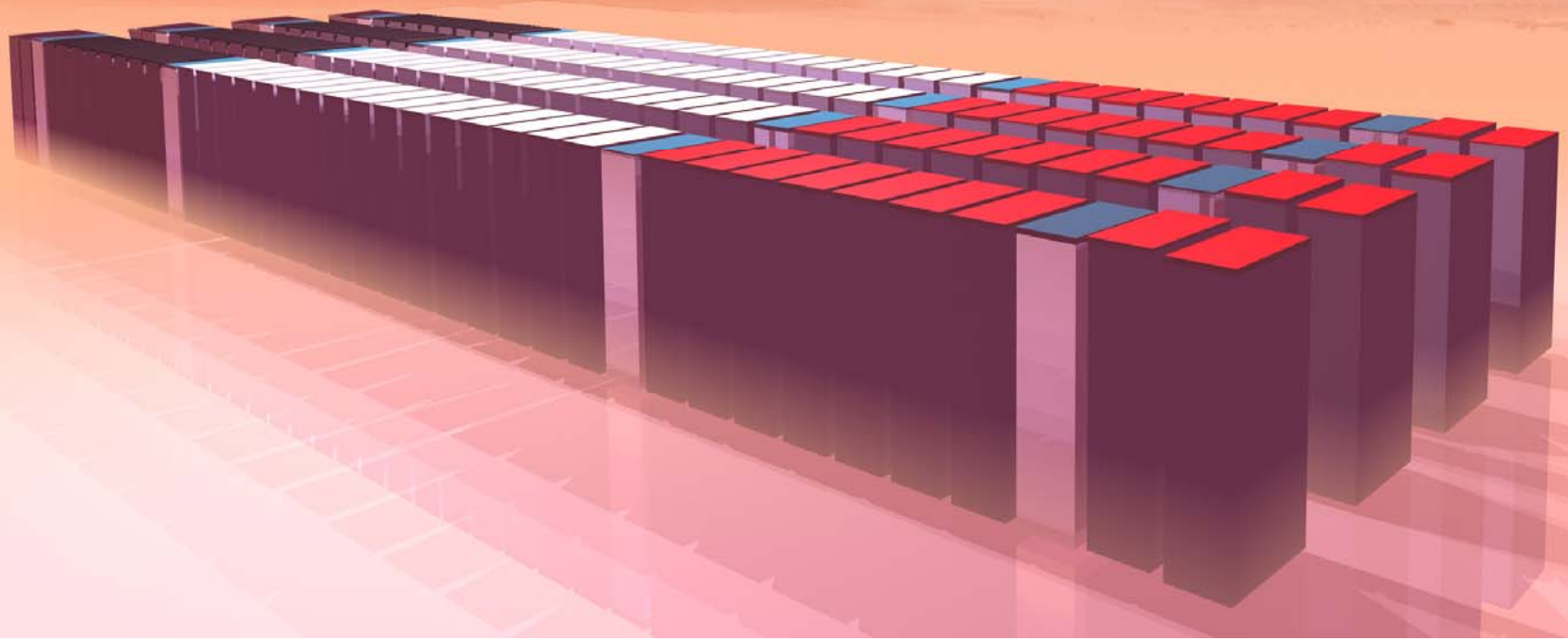
# Red Storm Architecture
# and
# Early Application Code Experience

**Jim Tomkins**

**Fall Creek Falls Conf, 10/16 - 10/18, 2005**



National Nuclear Security Administration

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# Red Storm Architecture

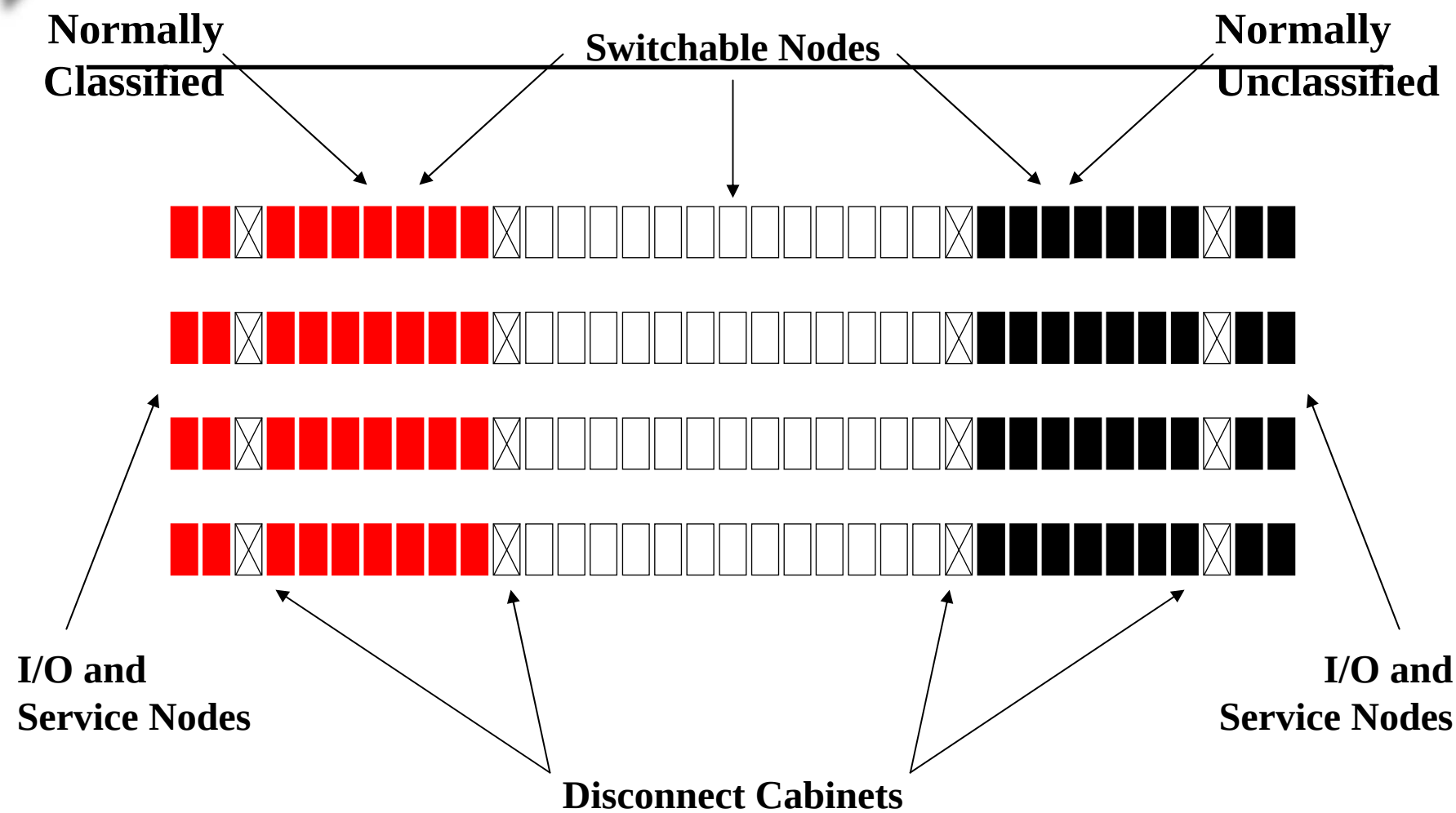
- Balanced System Performance: CPU, Memory, Interconnect and I/O
- Scalability: System Hardware and System Software scale, a single cabinet system to 32K processor system
- Functional Partitioning: Hardware and System Software
- Reliability: Full system Reliability, Availability, Serviceability (RAS) Designed into Architecture
- Upgradeability: Designed in path for system upgrade
- Red/Black Switching: Flexible support for both classified and unclassified Computing in a single system
- Custom Packaging: High density, relatively low power system
- Price/Performance: Excellent performance per dollar, use high volume commodity parts where feasible

# Red Storm System

- True MPP, designed to be a single system
- Distributed memory MIMD parallel supercomputer
- Fully connected 3-D mesh interconnect.
- 108 compute node cabinets and 10,368 compute node processors (AMD *Opteron* @ 2.0 GHz)
- ~30 TB of DDR compute node memory (4 GB, 3 GB, 2 GB)
- 8 Service and I/O cabinets on each end (256 processors for each color)
- ~400 TB of disk storage (~200 TB per color)
- Less than 2 MW total power and cooling
- Less than 3,000 $ft^2$ of floor space

# Red Storm Layout

## (27 × 16 × 24 Compute Node Mesh)




Disk storage system not shown

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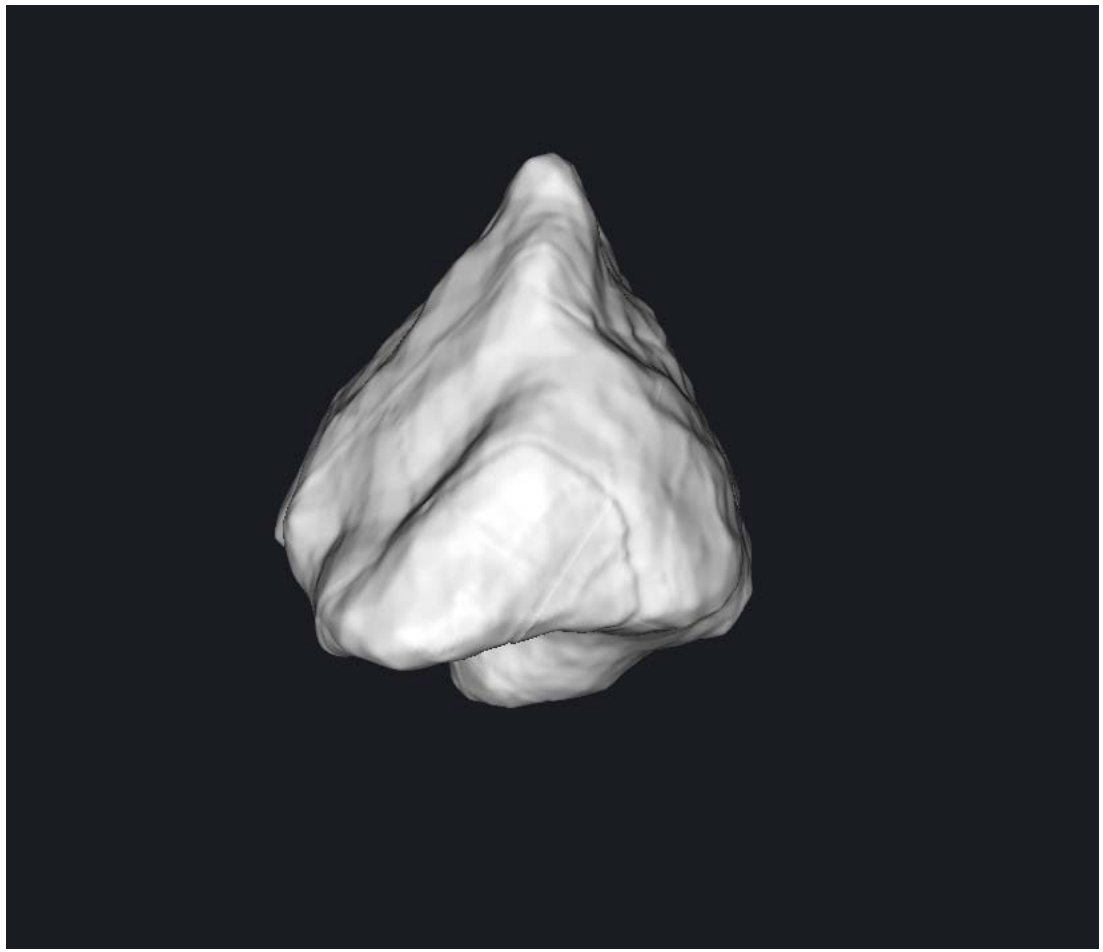
# Some Applications Running on Red Storm

- CTH (SNL) - Shock/Hydro
- Partisn (LANL) - Discrete Ordinates Radiation Transport
- ITS (SNL) - Monte-Carlo Radiation Transport
- Sage (LANL) - Hydro
- Salinas (SNL) - Structural Mechanics
- Alegra (SNL) - Hydro/ICF
- Presto (SNL) - Structural Dynamics
- Calore (SNL) - Heat Transfer
- Fuego (SNL) - Fire
- SEAM (NCAR) - Atmospheric Climate
- POP (LANL) - Ocean Model

# CTH

- 3-D explicit Shock/Hydro
- Structured grid
- Adaptive Mesh Refinement
- Fortran (mostly F77)
- Sandia production code that is also widely used in the DOD

# Golevka Asteroid

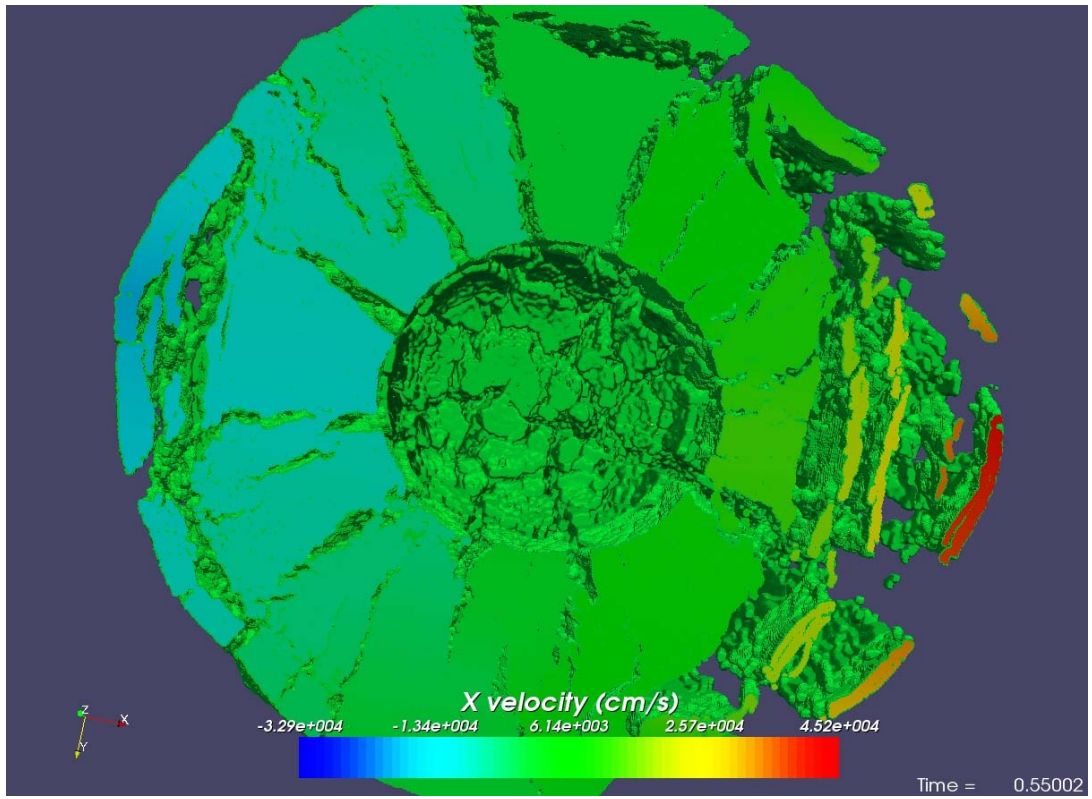


Asteroid is about 500m X 600m X 700m

High resolution solid model was created from an image created by joint work using three radio telescopes. The Goldstone antenna in California provided radar single that was reflected to the Evapatoria antenna in Russia and the Kashima antenna in Japan.

# CTH Calculation of Golevka Asteroid Explosion

**(Mark Boslough)**




- **10 MT Explosion at center of mass**
- **0.5 s simulation time**
- **Billion cell simulation, ~0.5m cell size**
- **7200 nodes of Red Storm**
- **>12 hr run**

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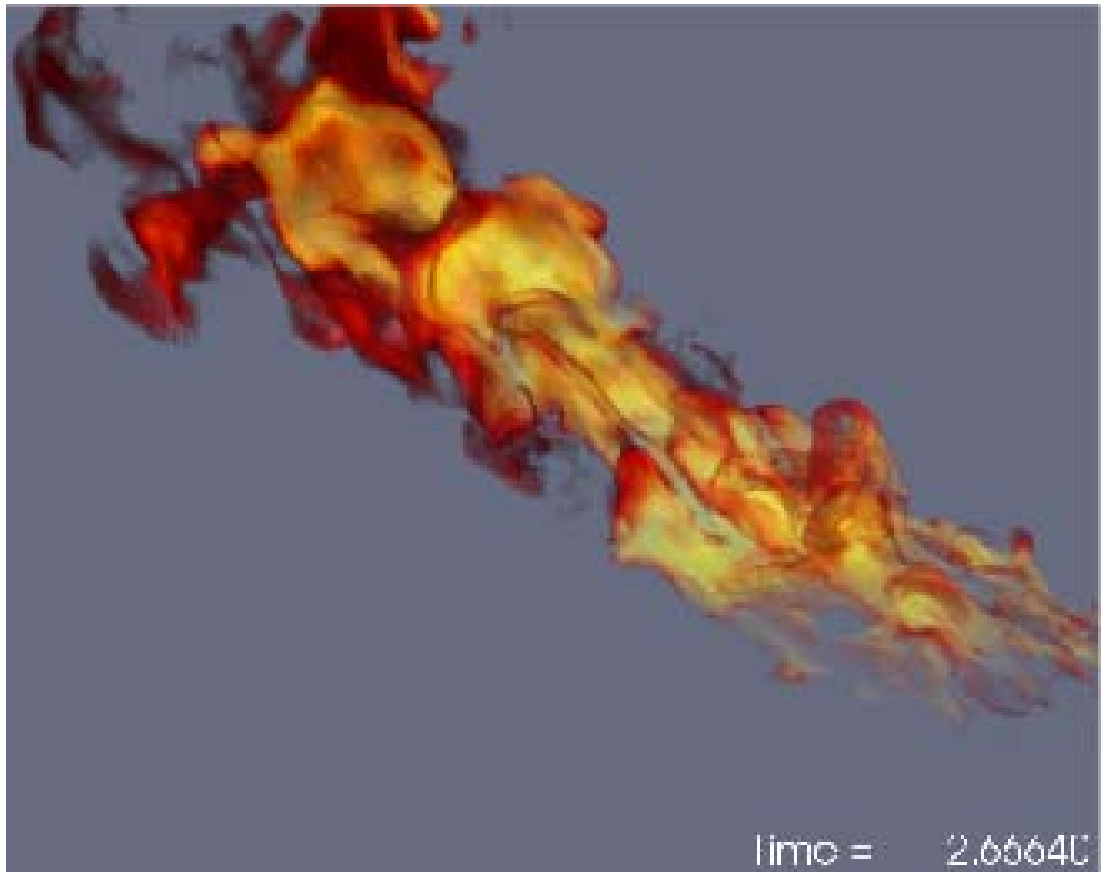
# Fuego Fire Code

- Fuego is part of Sandia's Sierra suite of codes.
- Finite Element
- AMR
- C++
- Coupled to Calore heat transfer code

# Fuego
## (Sheldon Tiezen)




- High Resolution Fire Simulation
- 1024 nodes on Red Storm
- Ran for over 23 continuous hrs.

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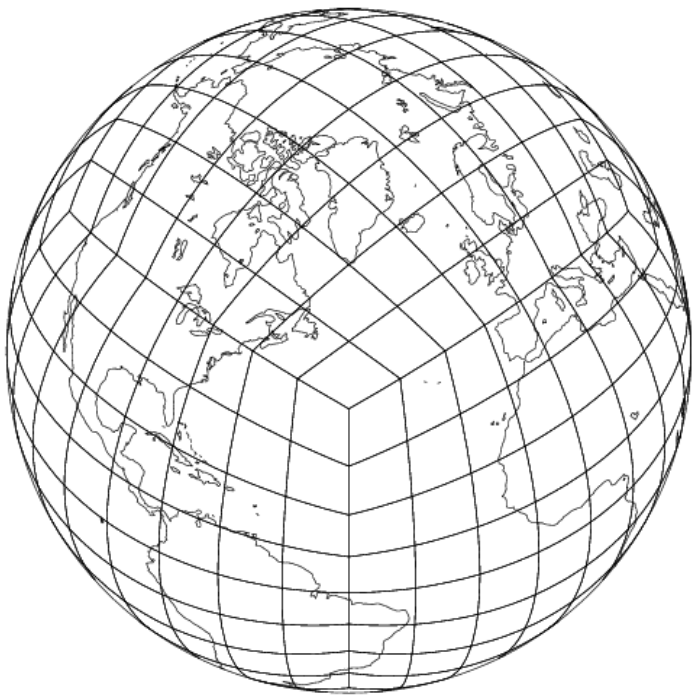
# SEAM
# (Spectral Element Atmospheric Model)



- Spectral elements replace spherical harmonics in horizontal directions
- Coupled to the Community Atmospheric Model (CAM)
- High order (p=8) finite element method with efficient Gauss-Lobatto quadrature used to invert the mass matrix.
- Two dimensional domain decomposition: each processor contains one or more elements and the vertical columns of data associated with those elements.

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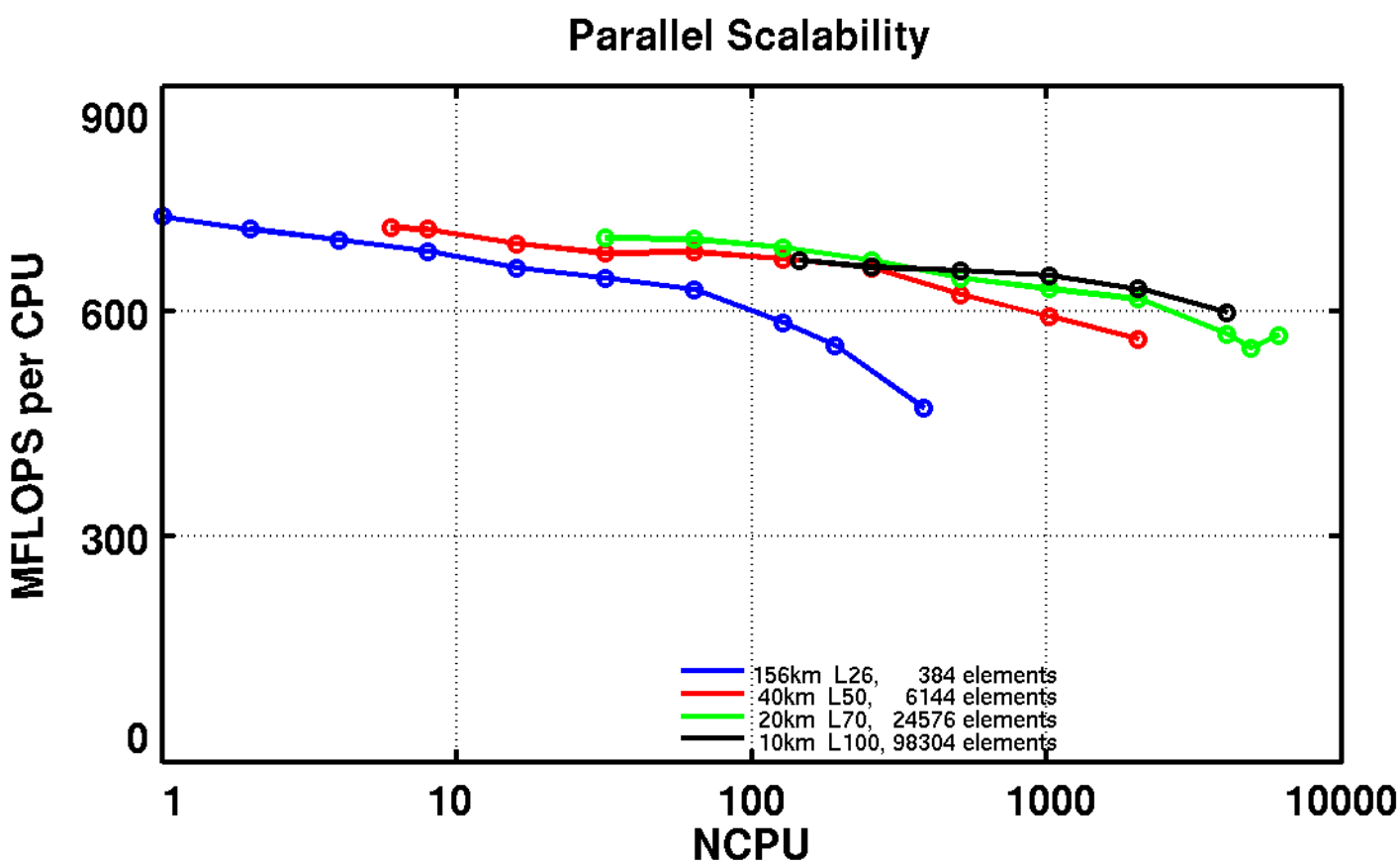
# SEAM Scalability on Red Storm

**(Mark Taylor)**




Performance of 4 fixed problem sizes, on up to 6K CPUs. The annotation gives the mean grid spacing at the equator (in km) and the number of vertical levels used for each problem.

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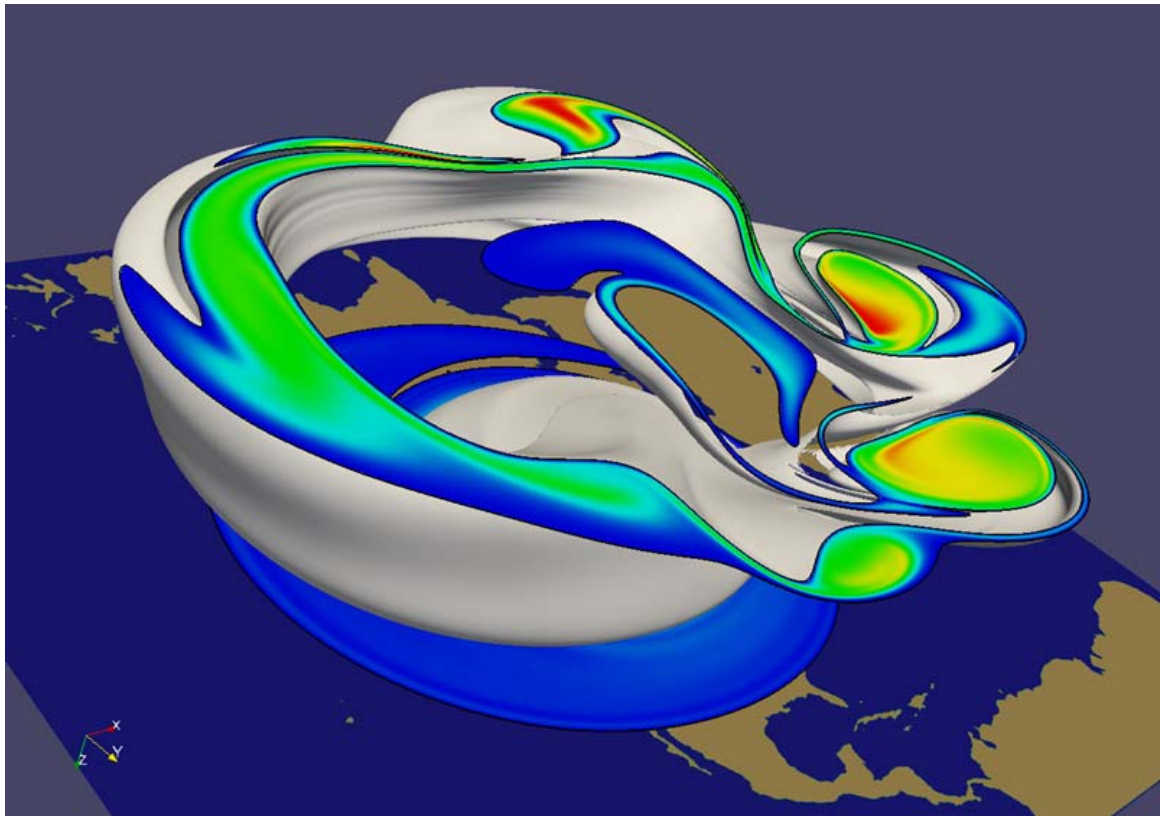
# SEAM
## (Mark Taylor)



- Billion grid point simulation of a polar vortex that has trapped air at the pole.
- Day 16 in a 20 day simulation.
- Run on 7200 nodes of Red Storm for 36 hrs.

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