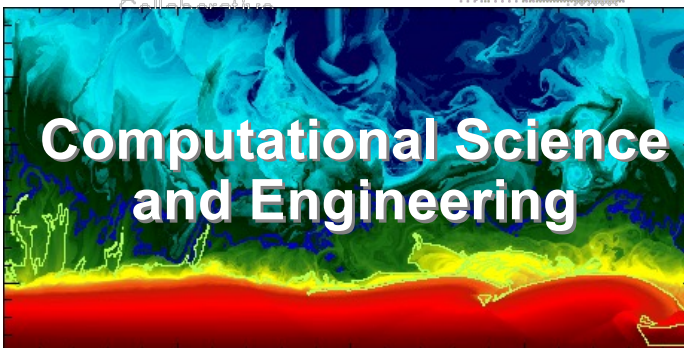
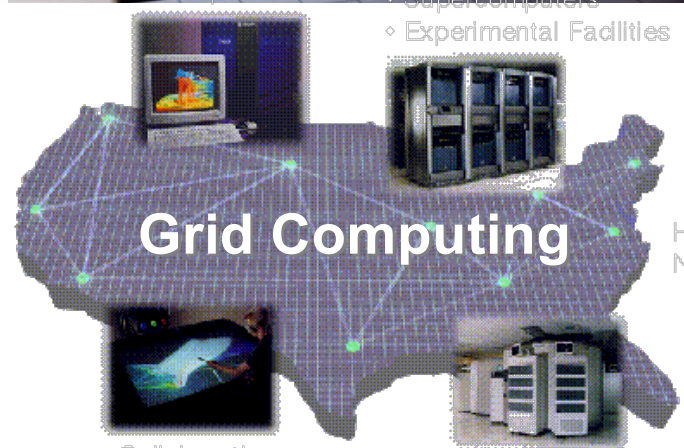


MCS Vision



- Increase by several orders of magnitude the computing power that can be applied to individual scientific problems, thus enabling progress in understanding complex physical and biological systems.
- Interconnect the world's most important scientific databases, computing systems, instruments and facilities to improve scientific productivity and remove barriers to collaboration.
- Make high-end computing a core tool for challenging modeling, simulation and analysis problems.

MCS Products/Resources

- **Enabling technologies**
 - “middleware”
 - “tools”
 - “support applications”
- **Scientific applications**
- **Hardware**
- **Other fundamental CS research**

Enabling Technologies

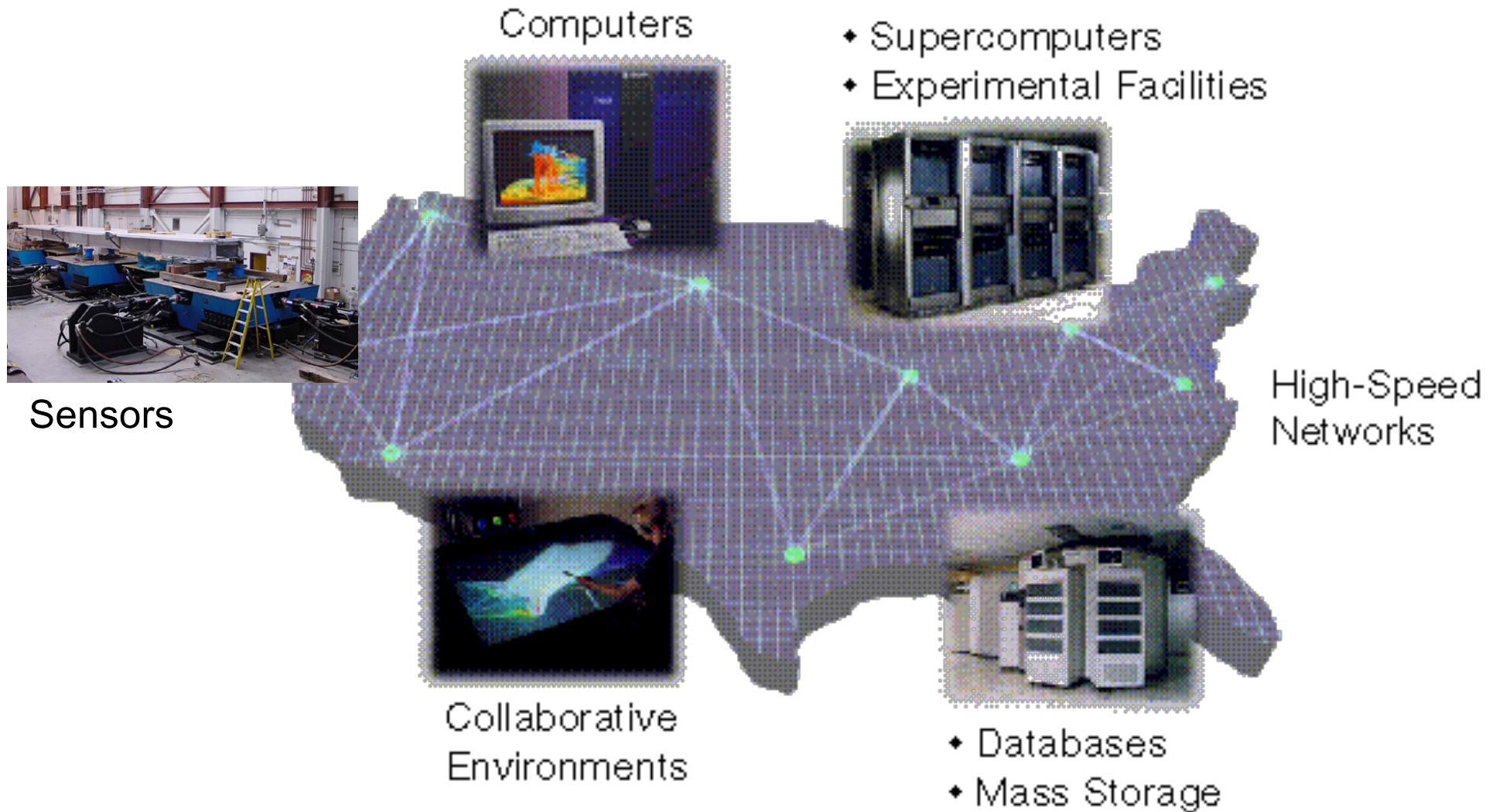
- **Globus Toolkit**
 - Software infrastructure/standards for Grid computing
- **MPICH**
 - Our free implementation of MPI
- **Jumpshot**
 - Software for analysis of message passing
- **pNetCDF**
 - High performance parallel I/O library
- **PetsC**
 - Toolkit for parallel matrix solves
- **Visualization** (“**Futures lab**”)
 - Scalable parallel visualization software, large-scale displays
- **Access Grid**
 - Collaboration environment

Collaboration Technology – the Access Grid

- Multi-way meetings and conferences over the Internet
- Using high-quality video/audio technology
- Large format display: 200+ installations worldwide
- Easily replicated configurations, open source software
- www.accessgrid.org



*The **Grid** Links People with Distributed Resources on a National Scale*



Some key scientific applications

- **Flash**
 - Community code for general Astrophysical phenomena
 - ASCI project with UC
- **Nek5**
 - Biological fluids
- **pNeo**
 - Neo-cortex simulations for study of epileptic seizures
- **QMC**
 - Monte Carlo simulations of atomic nuclei
- **Nuclear Reactor Simulations**

Hardware

Chiba City – Software Scalability R&D

Addresses scalability issues in system software, open source software, and applications code.
512 CPUs, 256 nodes, Myrinet, 2TB storage, Linux.
DOE OASCR funded. Installed in 1999.



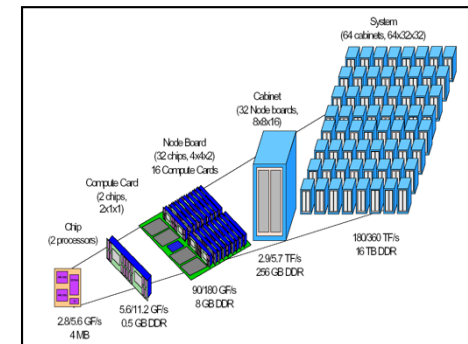
Jazz – Linux Cluster for ANL Applications

Supports and enhances ANL application community.
50+ projects from a spectrum of S&E divisions
350 CPUs, Myrinet, 20TB storage.
ANL funded. Installed in 2002. Achieved 1.1 TF sustained.



Blue Gene prototype – coming soon

two-rack system scalable to twenty racks

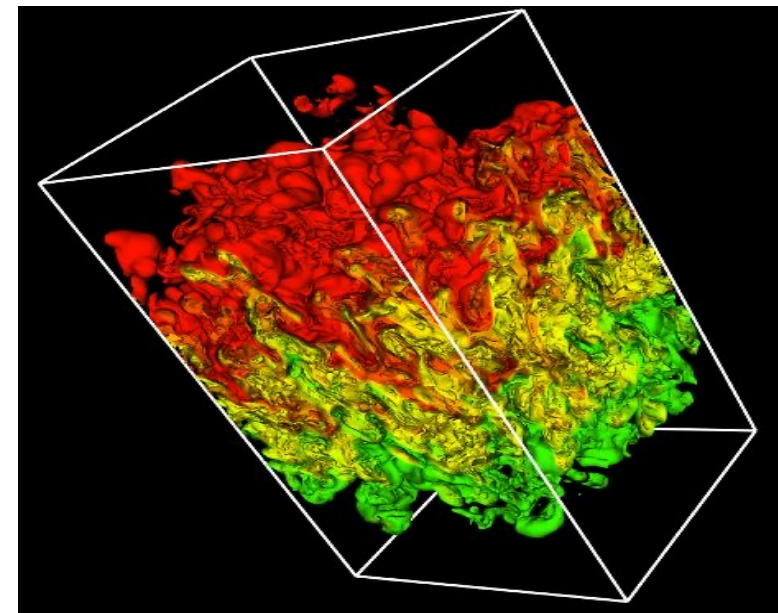
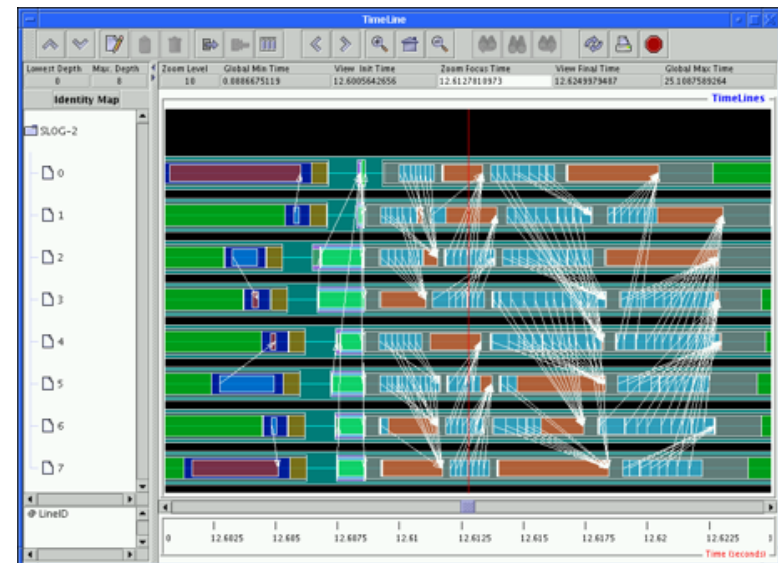


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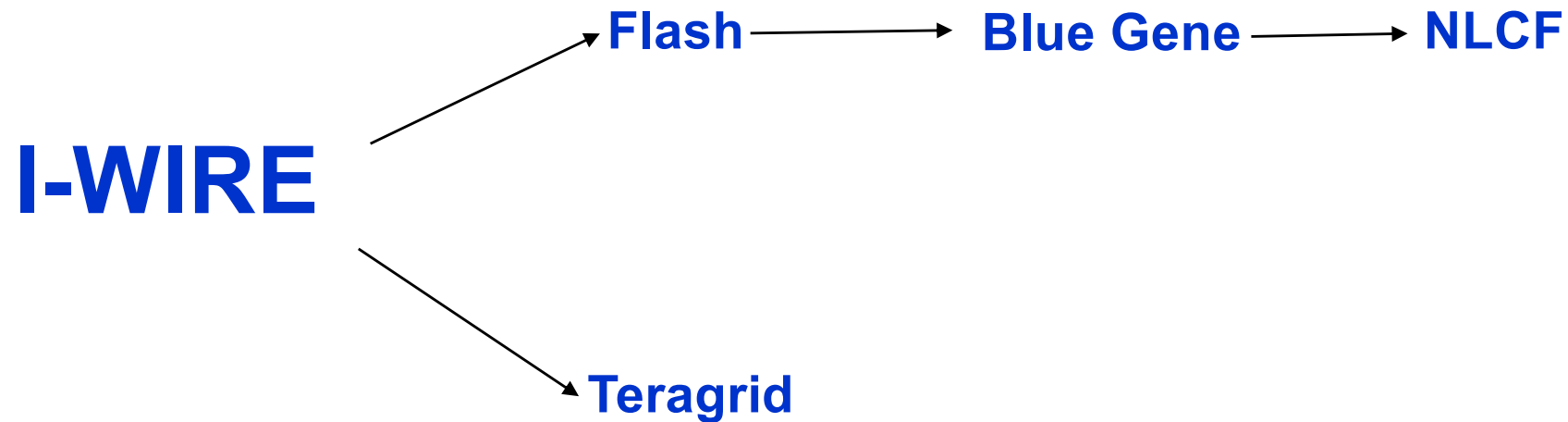
Other HPC areas

- **Architecture and Performance Evaluation**
- **Programming Models and Languages**
- **Systems Software**
- **Numerical Methods and Optimization**
- **Software components**
- **Software Verification**
- **Automatic Differentiation**

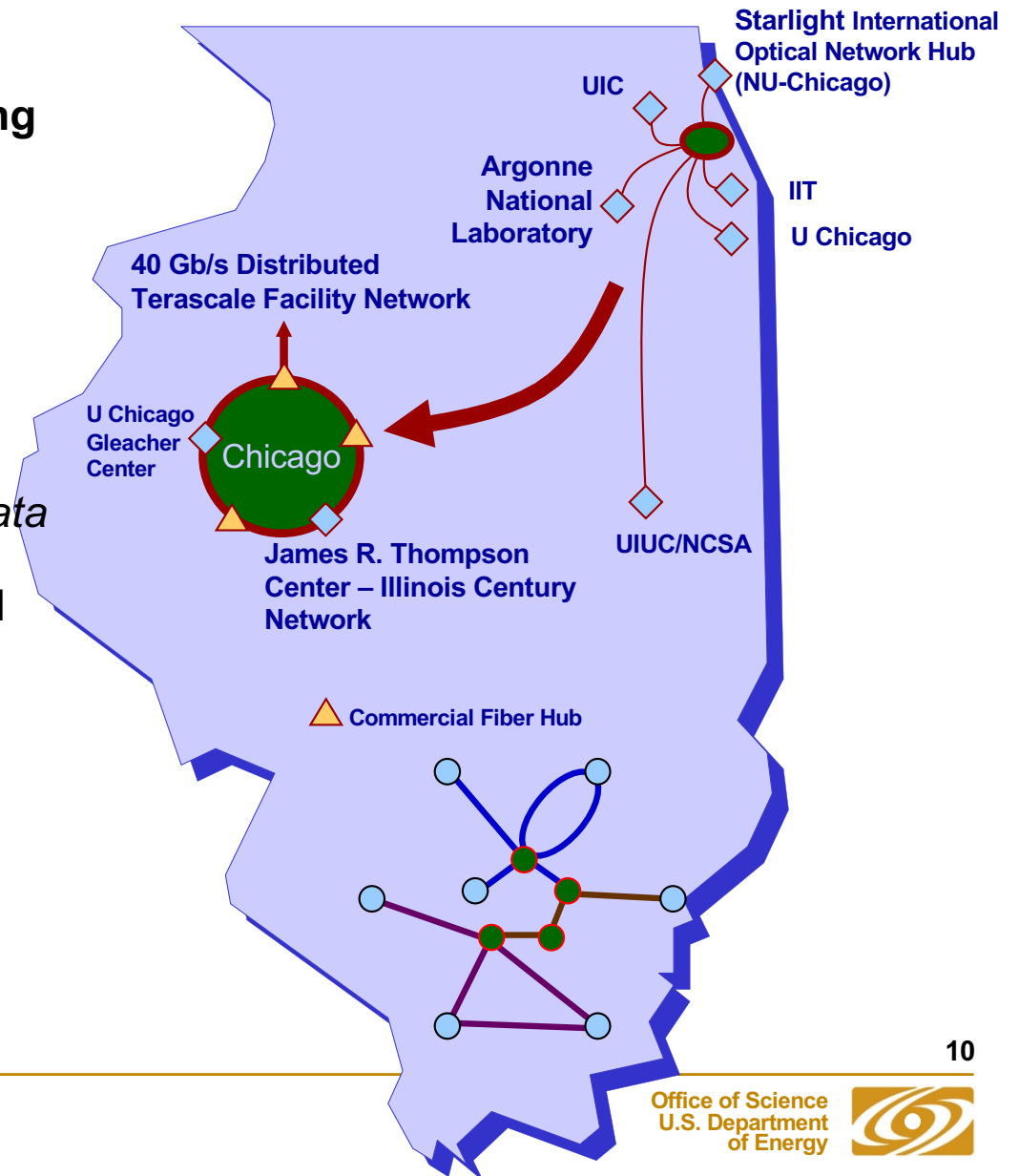


I-Wire Impact

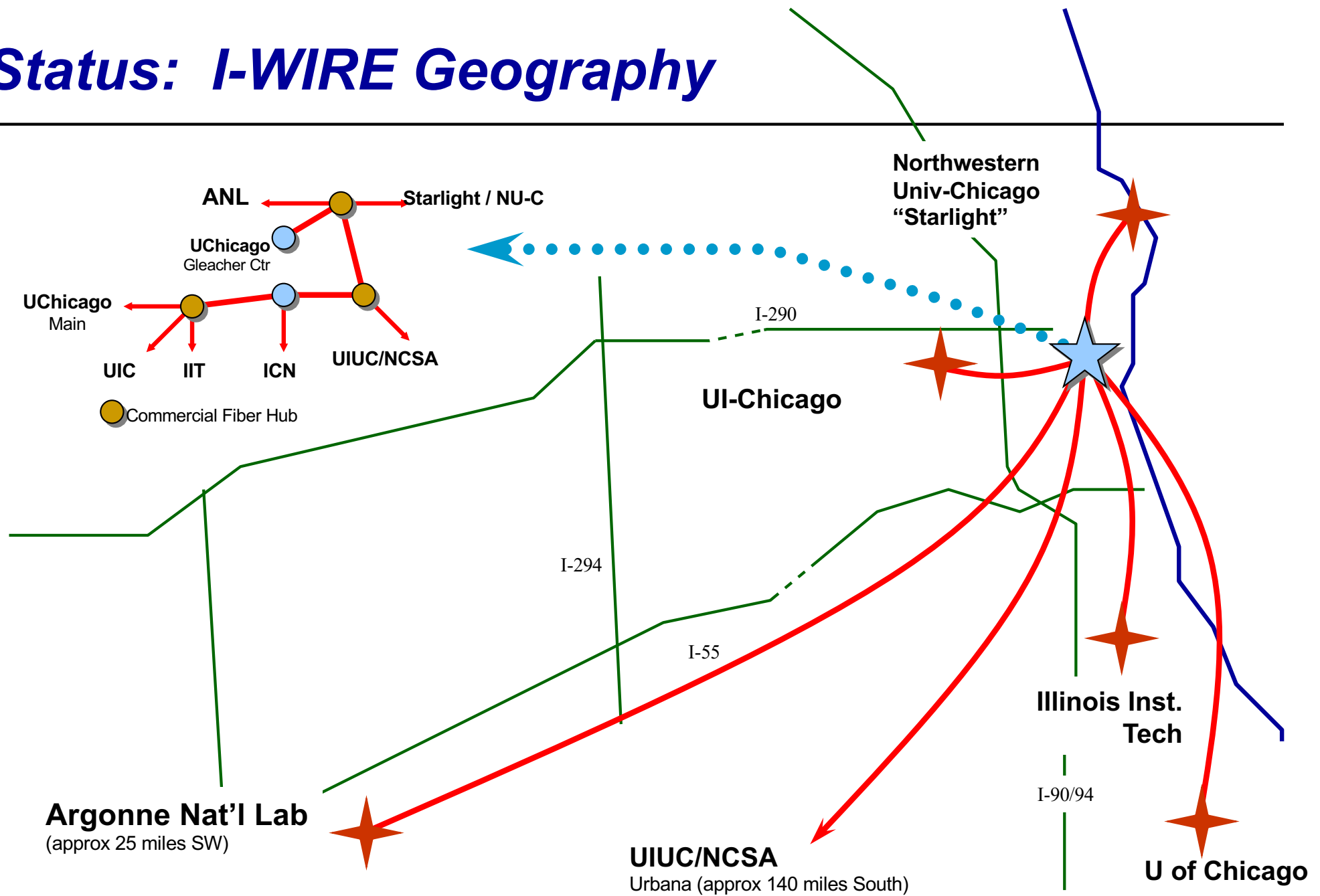
Two concrete examples of the impact of I-WIRE



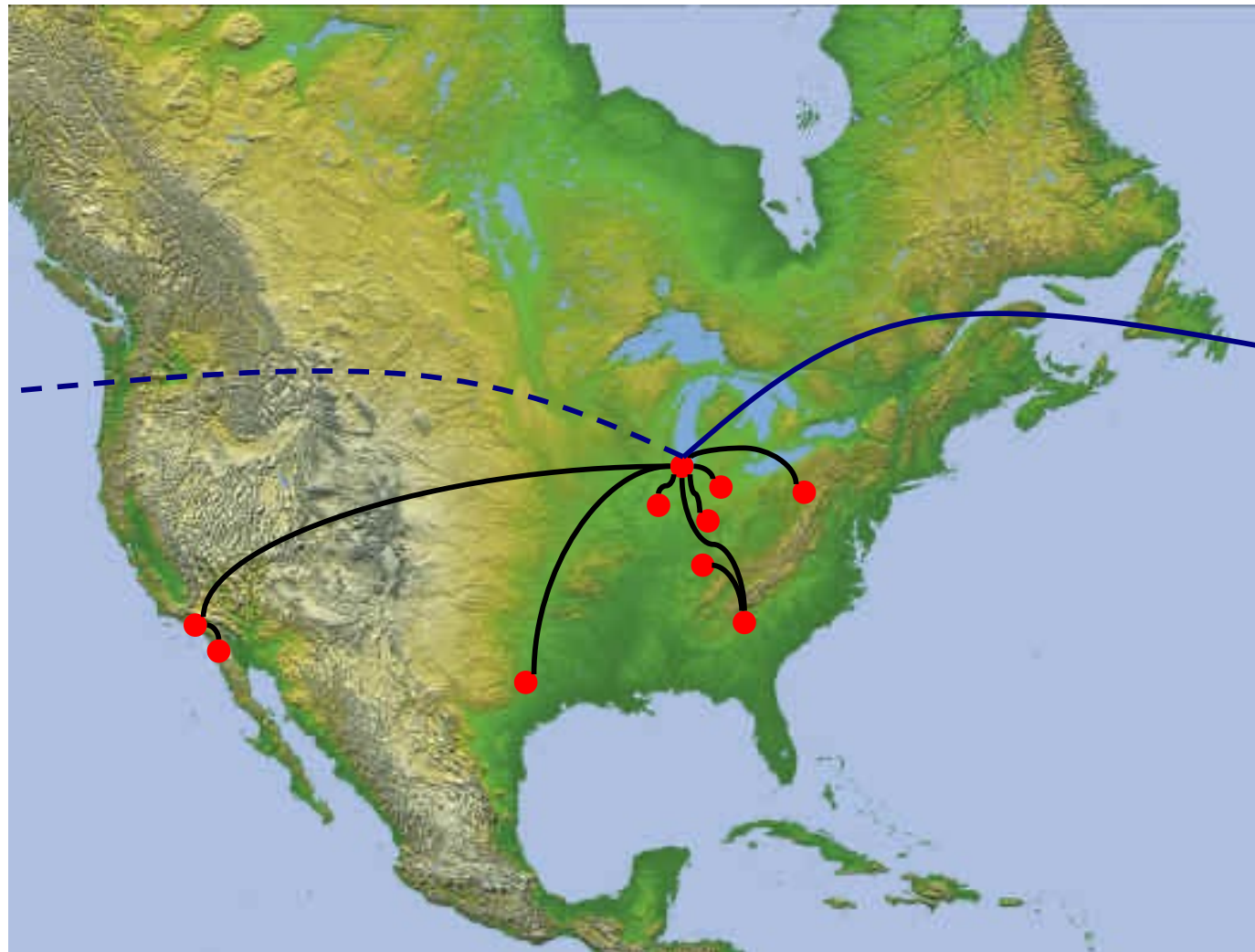
- **State Funded Dark Fiber Optical Infrastructure to support Networking and Applications Research**
 - \$11.5M Total Funding
 - \$6.5M FY00-03
 - \$5M in process for FY04-5
 - Application Driven
 - *Access Grid: Telepresence & Media*
 - *TeraGrid: Computational and Data Grids*
 - New Technologies Proving Ground
 - *Optical Network Technologies*
 - *Middleware and Computer Science Research*
- **Deliverables**
 - A flexible infrastructure to support advanced applications and networking research



Status: I-WIRE Geography



TeraGrid Vision: A Unified National HPC Infrastructure that is Persistent and Reliable



- Largest NSF compute resources
- Largest DOE instrument (SNS)
- Fastest network
- Massive storage
- Visualization instruments
- Science Gateways
- Community databases

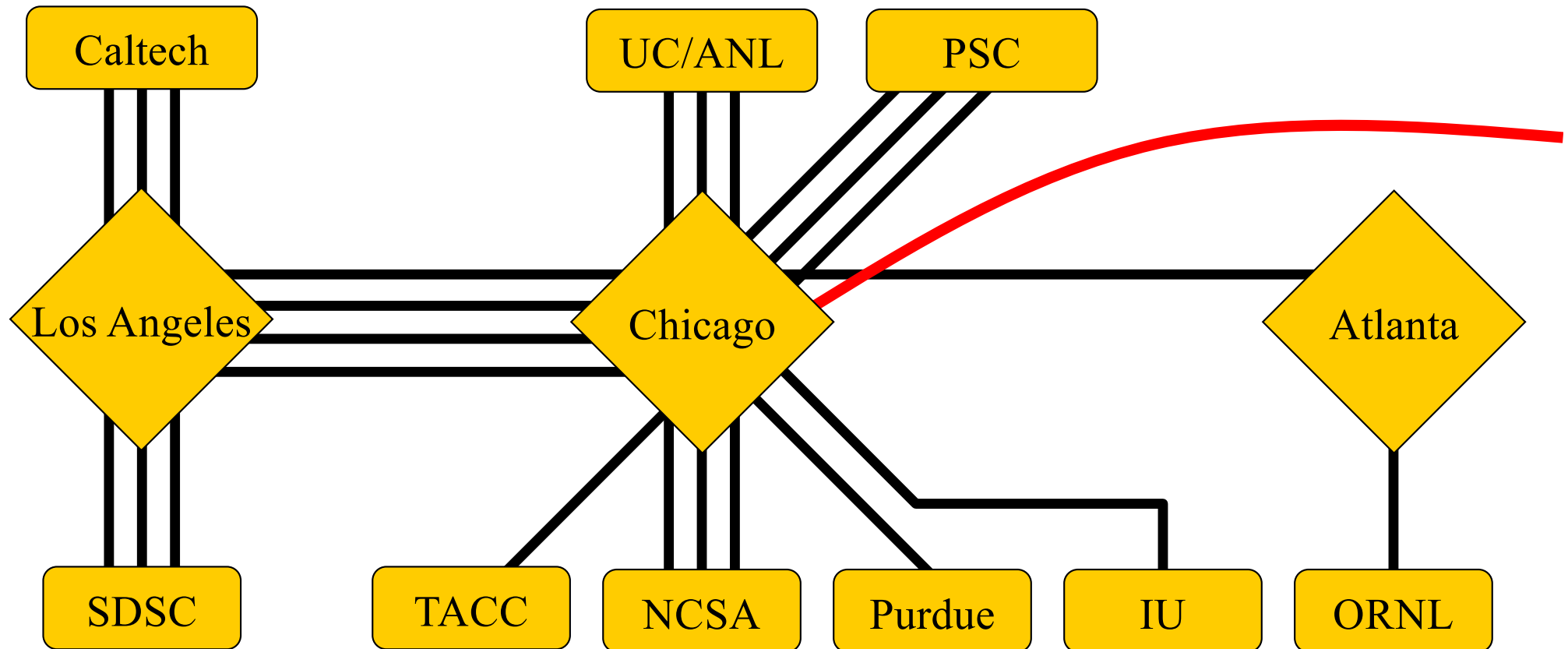
E.g: Geosciences: 4 data collections including high-res CT scans, global telemetry data, worldwide hydrology data, and regional LIDAR terrain data

Resources and Services

(33TF, 1.1PB disk, 12 PB tape)



Current TeraGrid Network

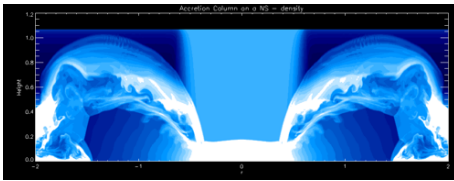


Resources: Compute, Data, Instrument, Science Gateways

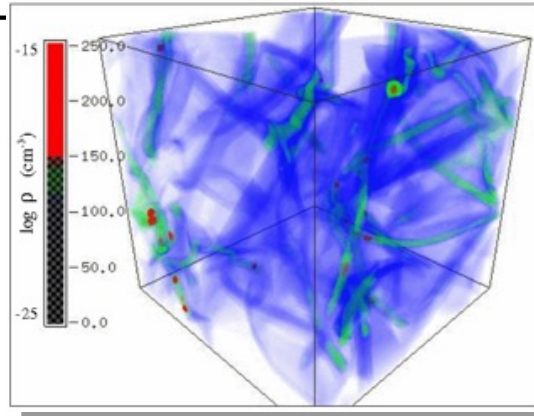
Flash

- **Flash Project**
 - Community Astrophysics code
 - DOE funded ASCI program at UC/Argonne
 - 4 million per year over ten years
 - Currently in 7th year
- **Flash Code/Framework**
 - Heavy emphasis on software engineering, performance, and usability
 - 500+ downloads
 - Active user community
 - Runs on all major hpc platforms
 - Public automated testing facility
 - Extensive user documentation

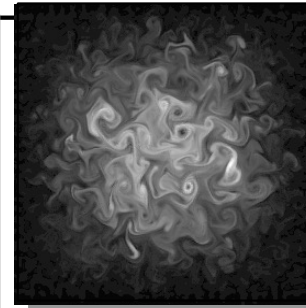
Flash -- Simulating Astrophysical processes



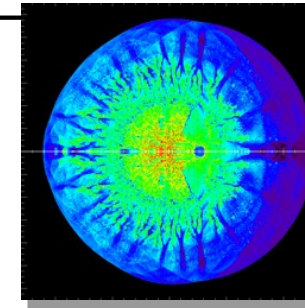
Shortly: Relativistic accretion onto NS



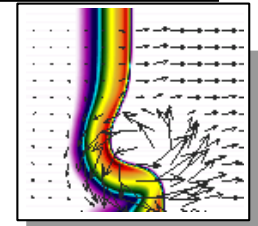
Gravitational collapse/Jeans instability



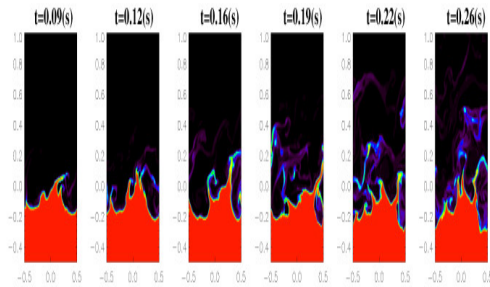
Compressed turbulence



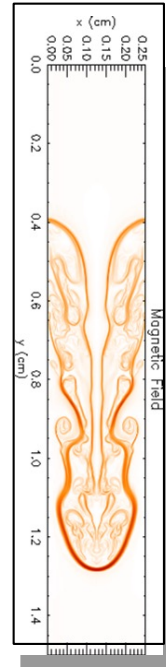
Type Ia Supernova



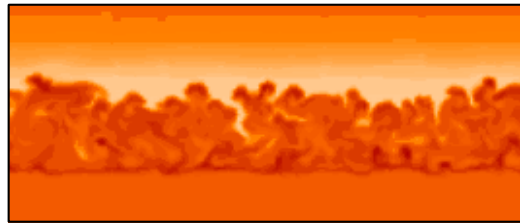
Flame-vortex interactions



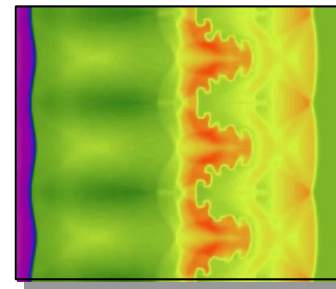
Wave breaking on white dwarfs



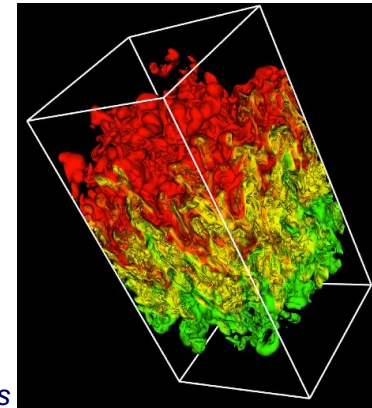
Magnetic
Rayleigh-Taylor



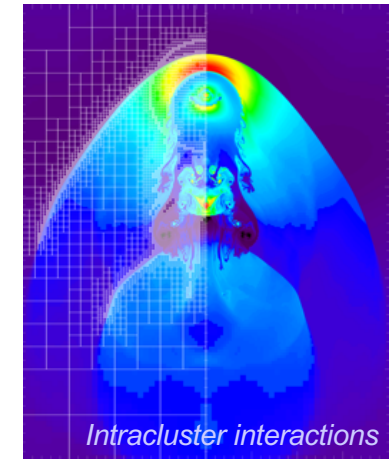
Nova outbursts on white dwarfs



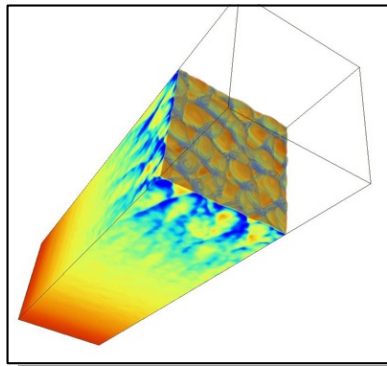
Laser-driven shock instabilities



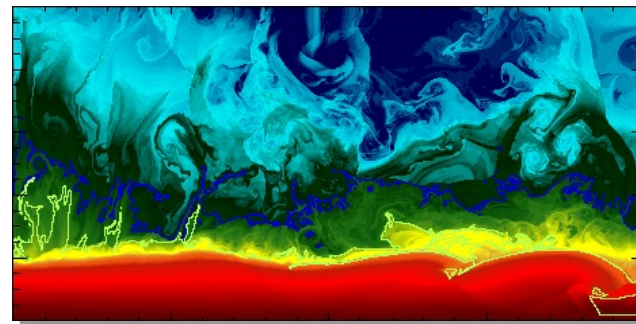
Rayleigh-Taylor instability



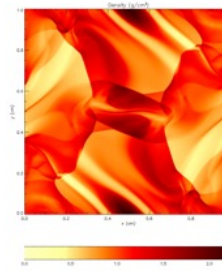
Intracluster interactions



Cellular detonation



Helium burning on neutron stars



Orzag/Tang MHD
vortex



Richtmyer-Meshkov instability

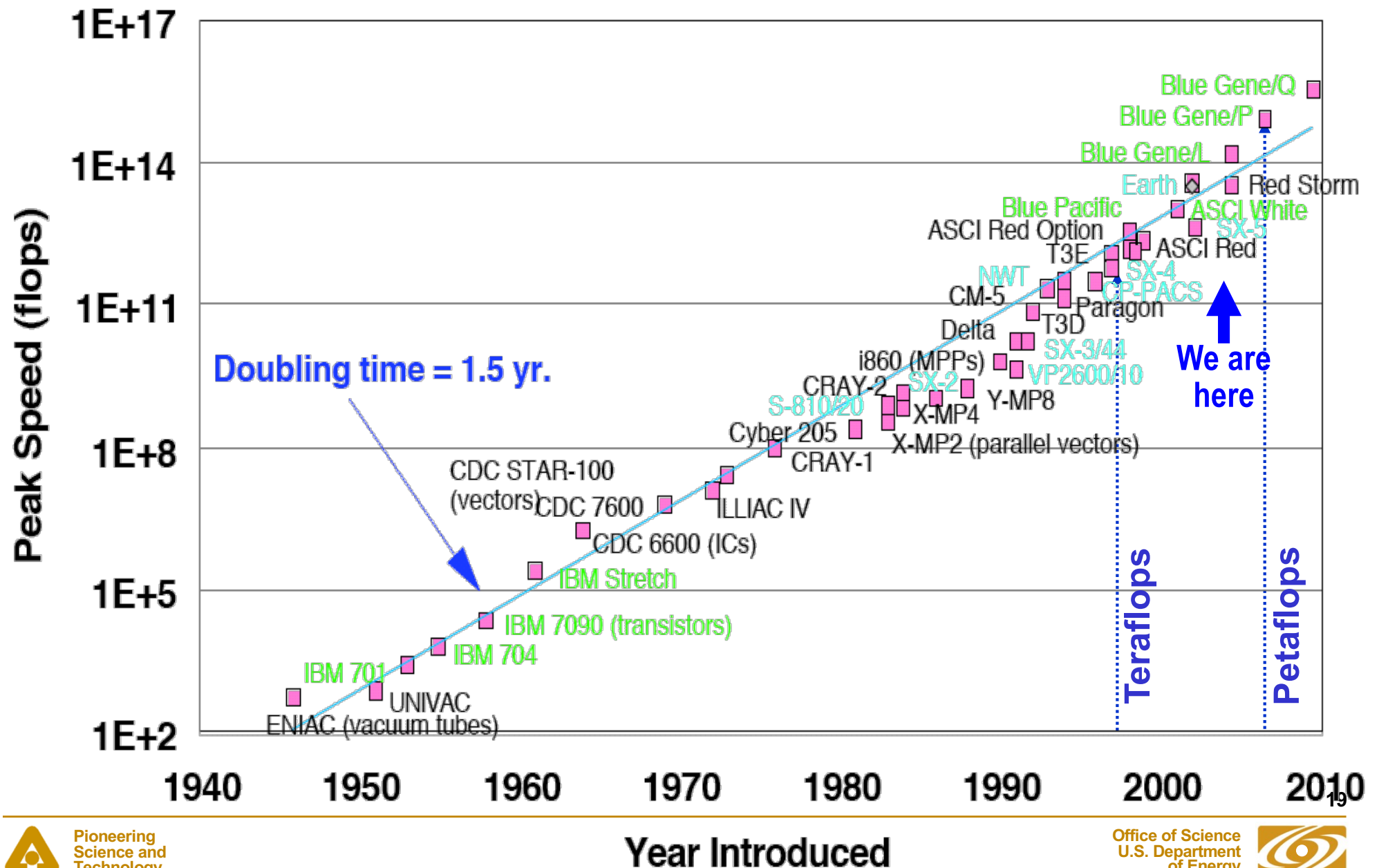
How has fast network helped Flash?

- **Flash in production for five years**
- **Generating terabytes of data**
- **Currently done “by hand”**
 - Data transferred locally from supercomputing centers for visualization/analysis
 - Data remotely visualized at UC using Argonne servers
 - Can harness data storage across several sites
- **Not just “visionary” grid ideas that are useful. Immediate “mundane” things as well!**

Buoyed Progress in HPC

- **FLASH flagship application for BG/L**
 - Currently being run on 4K processors at Watson
 - Will run on 16K procs in several months
- **Argonne partnership with Oak Ridge for National Leadership Class Computing Facility**
 - Non-classified computing
 - BG at Argonne
 - X1, Black Widow at ORNL
 - Application focus groups apply for time

Petaflops Hardware is Just Around the Corner



Diverse Architectures for Petaflop Systems

v IBM – Blue Gene

- Puts processors + cache + network interfaces on same chip
- Achieves high packaging density, low power consumption

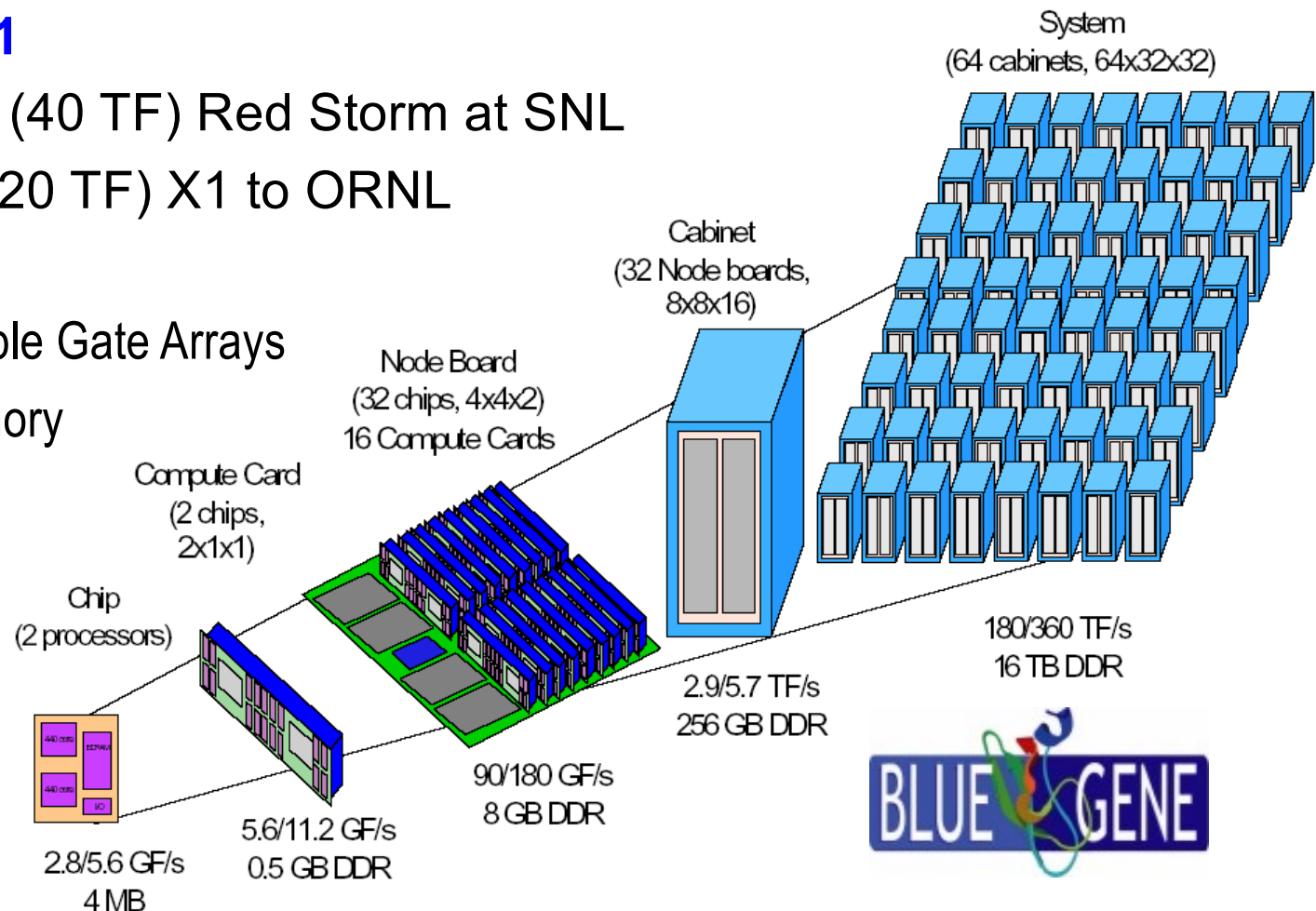
v Cray – RS and X1

- 10K processor (40 TF) Red Storm at SNL
- 1K processor (20 TF) X1 to ORNL

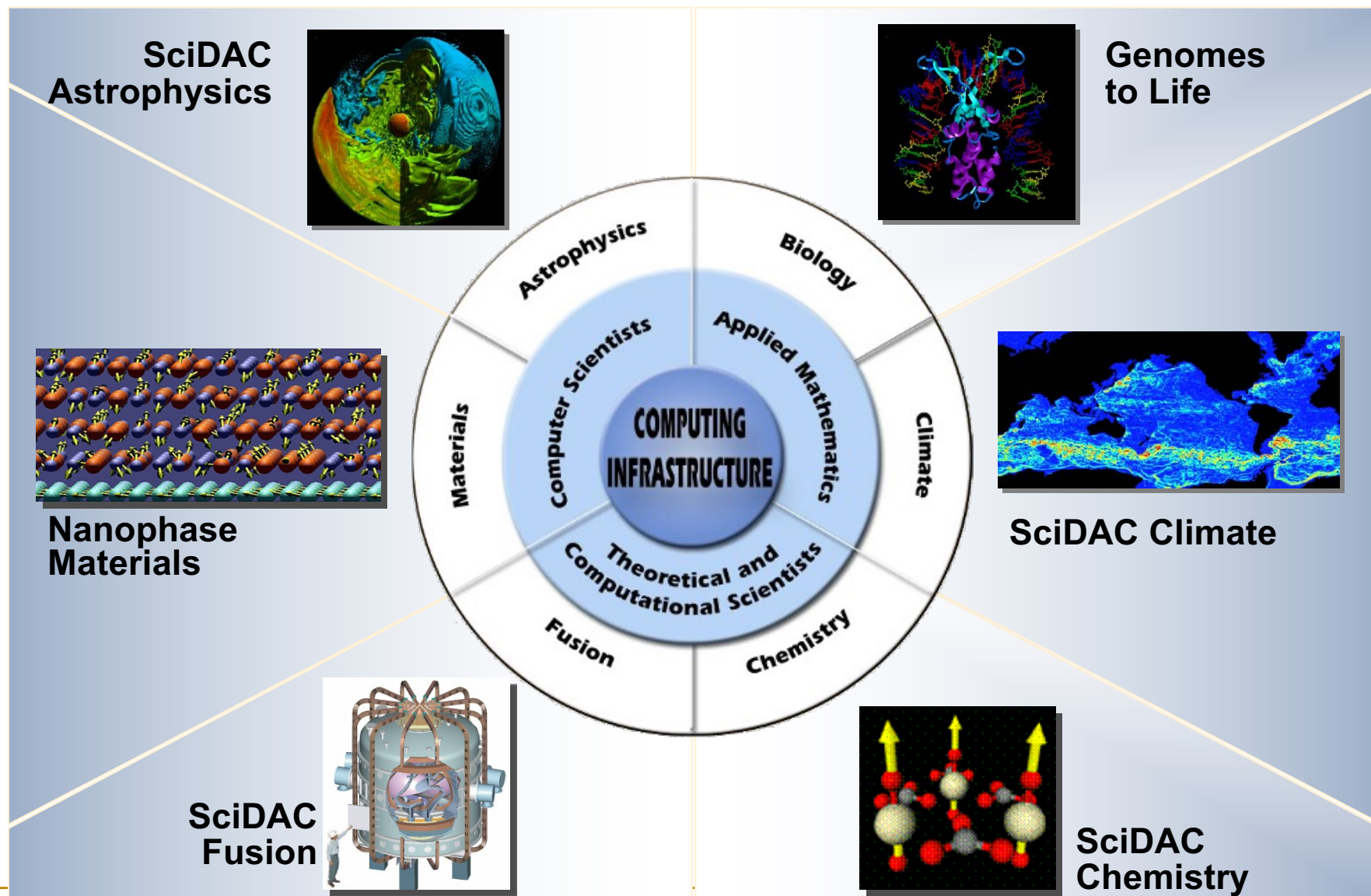
• Emerging

- Field Programmable Gate Arrays
- Processor in Memory
- Streams ...

v = systems slated for DOE National Leadership Computing Facility



NLCF Target Application Areas

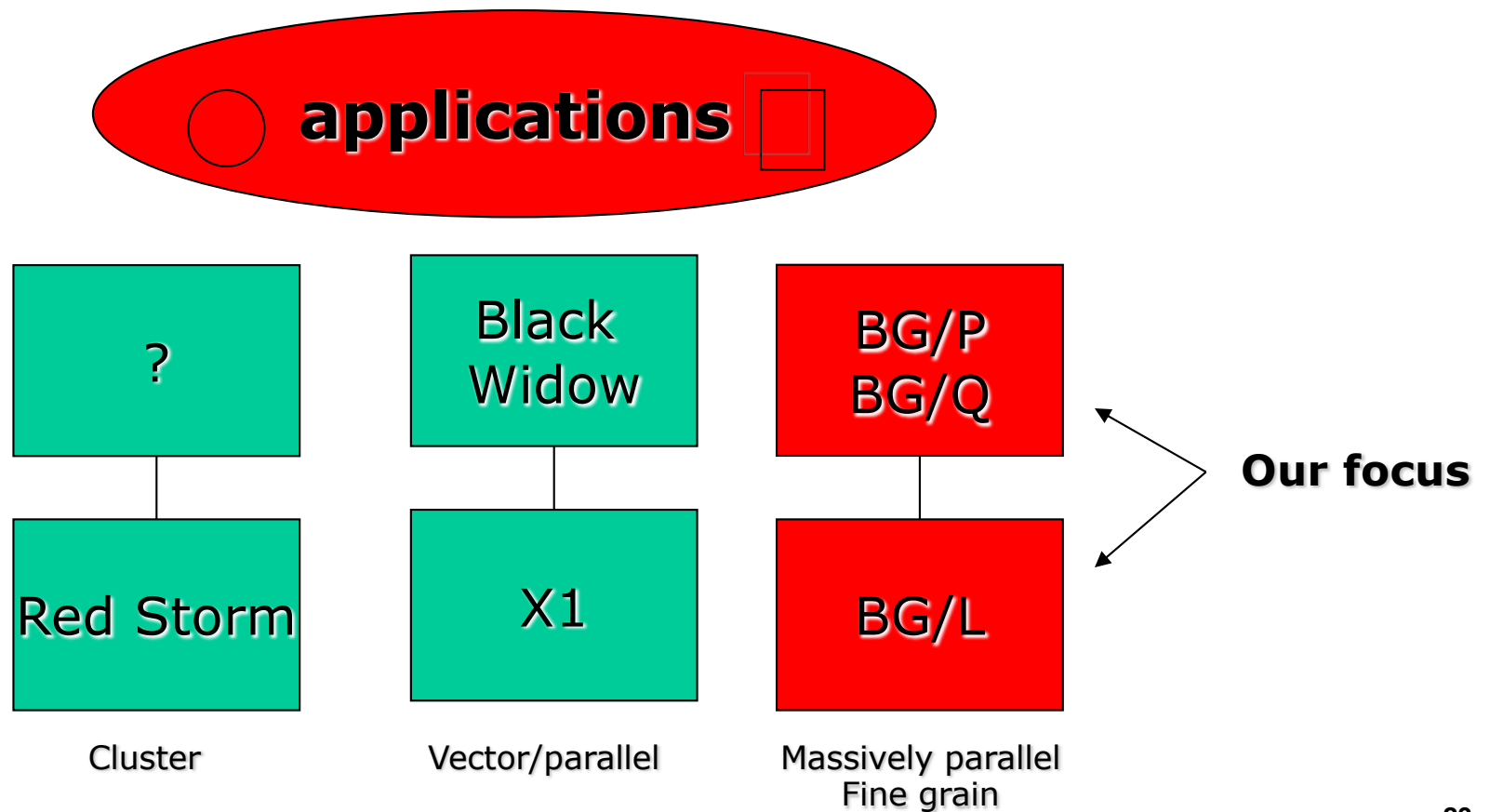


The Blue Gene Consortium: Goals

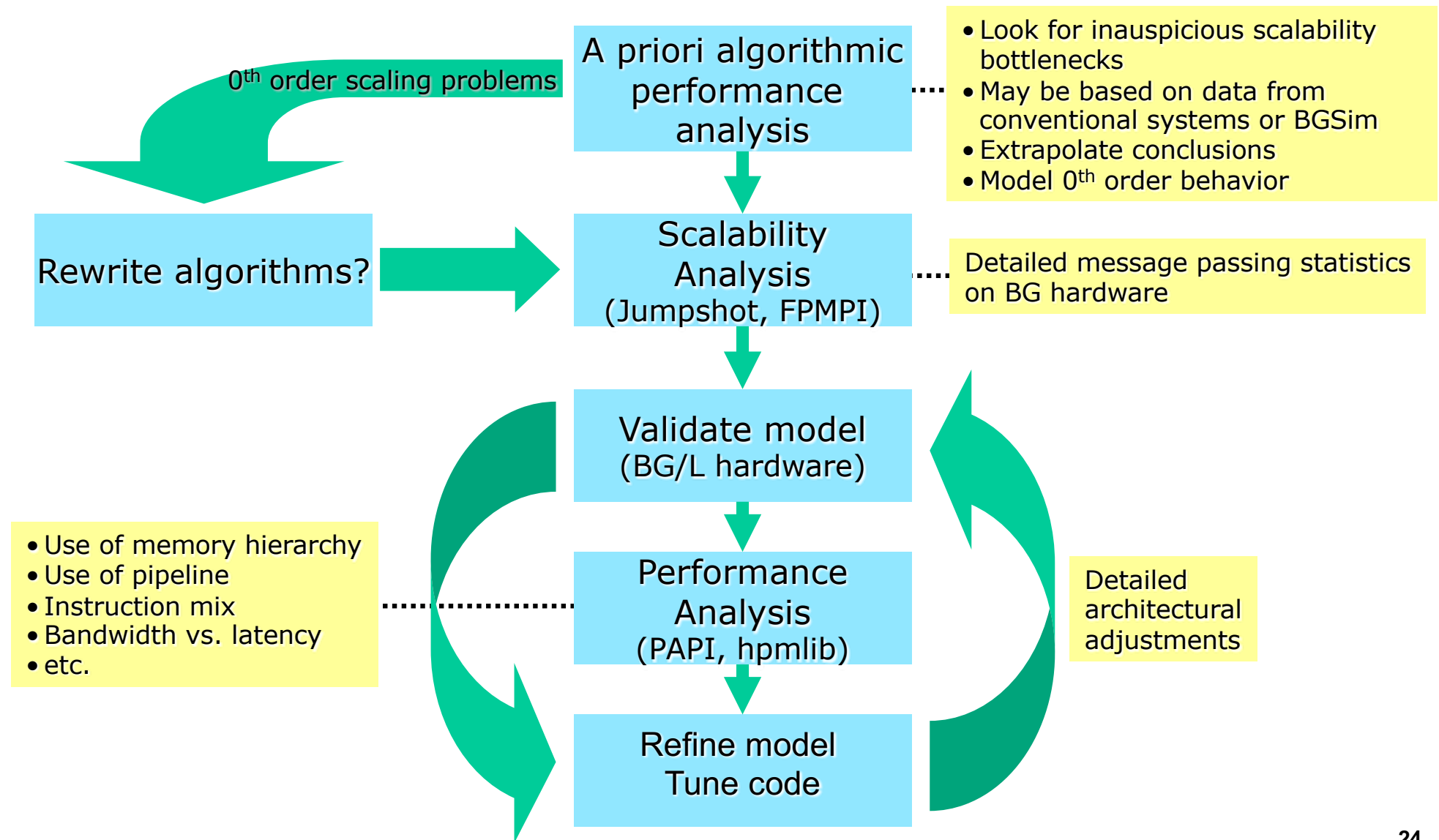
- **Provide new capabilities to selected applications partnerships.**
- **Provide functional requirements for a petaflop/sec version of BG.**
- **Build a community around a new class of architecture.**
 - Thirty university and lab partners
 - About ten hardware partners and about twenty software collaborators
- **Develop a new, sustainable model of partnership.**
 - “Research product” by passing normal “productization” process/costs
 - Community-based support model (hub and spoke)
- **Engage (or re-engage) computer science researchers with high-performance computing architecture.**
 - Broad community access to hardware systems
 - Scalable operating system research and novel software research
- **Partnership of DOE, NSF, NIH, NNSA, and IBM will work on computer science, computational science, and architecture development.**
- **Kickoff meeting was April 27, 2004, in Chicago.**

Determining application fit

- How will applications map onto different petaflop architectures?



Application Analysis Process



High performance resources operate in complex and highly distributed environments

TERAGRID



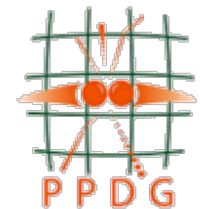
- **Argonne co-founded the Grid**

- Establishing a persistent, standards-based infrastructure and applications interfaces that enable high performance access to computation and data
- ANL created the Global Grid Forum, an international standards body
- We lead development of the Globus Toolkit



- **ANL staff are PIs and key contributors in many grid technology development and application projects**

- High performance data transport, Grid security, virtual organization mgt., Open Grid Services Architecture, ...
- Access Grid – group-to-group collaboration via large multimedia displays



NEESgrid

