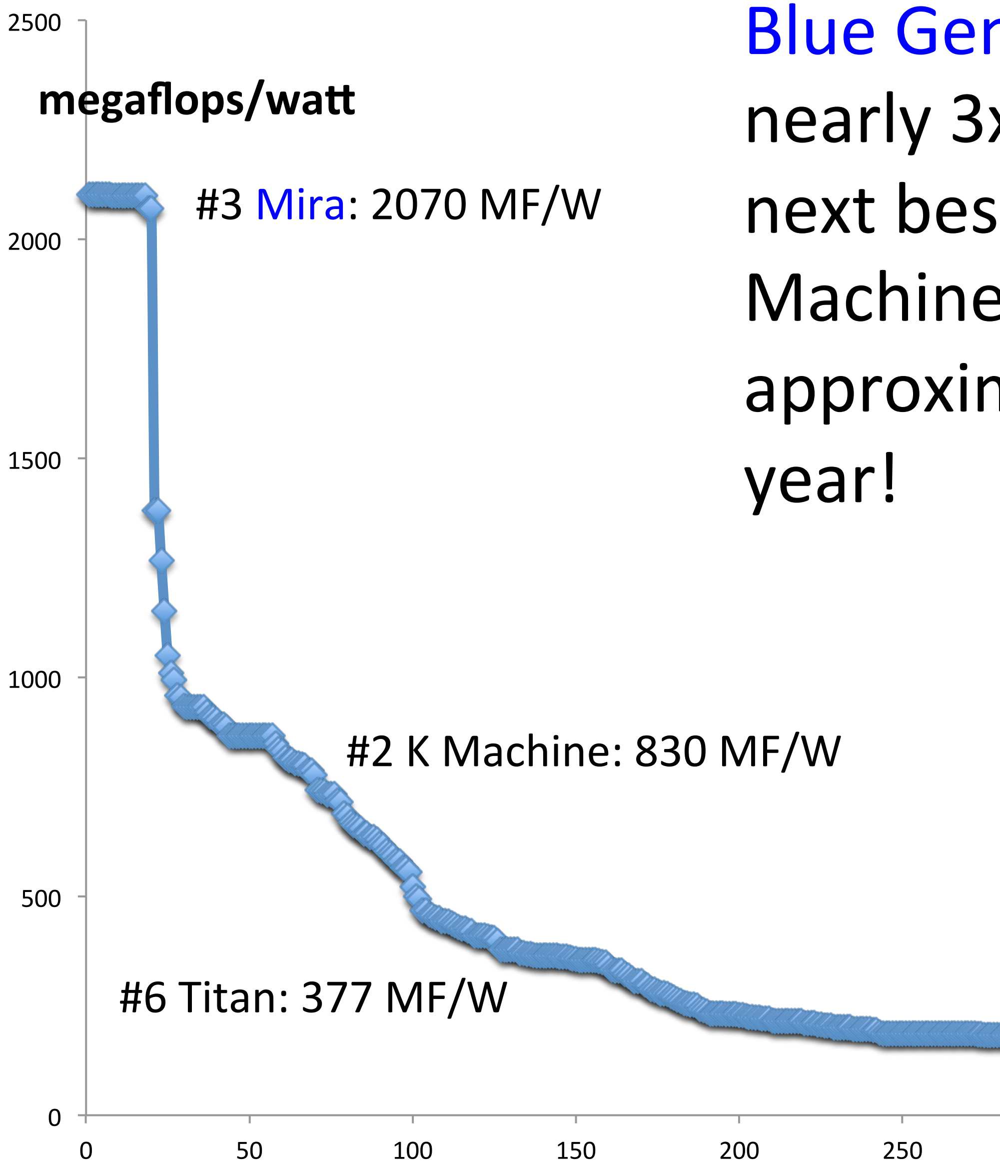
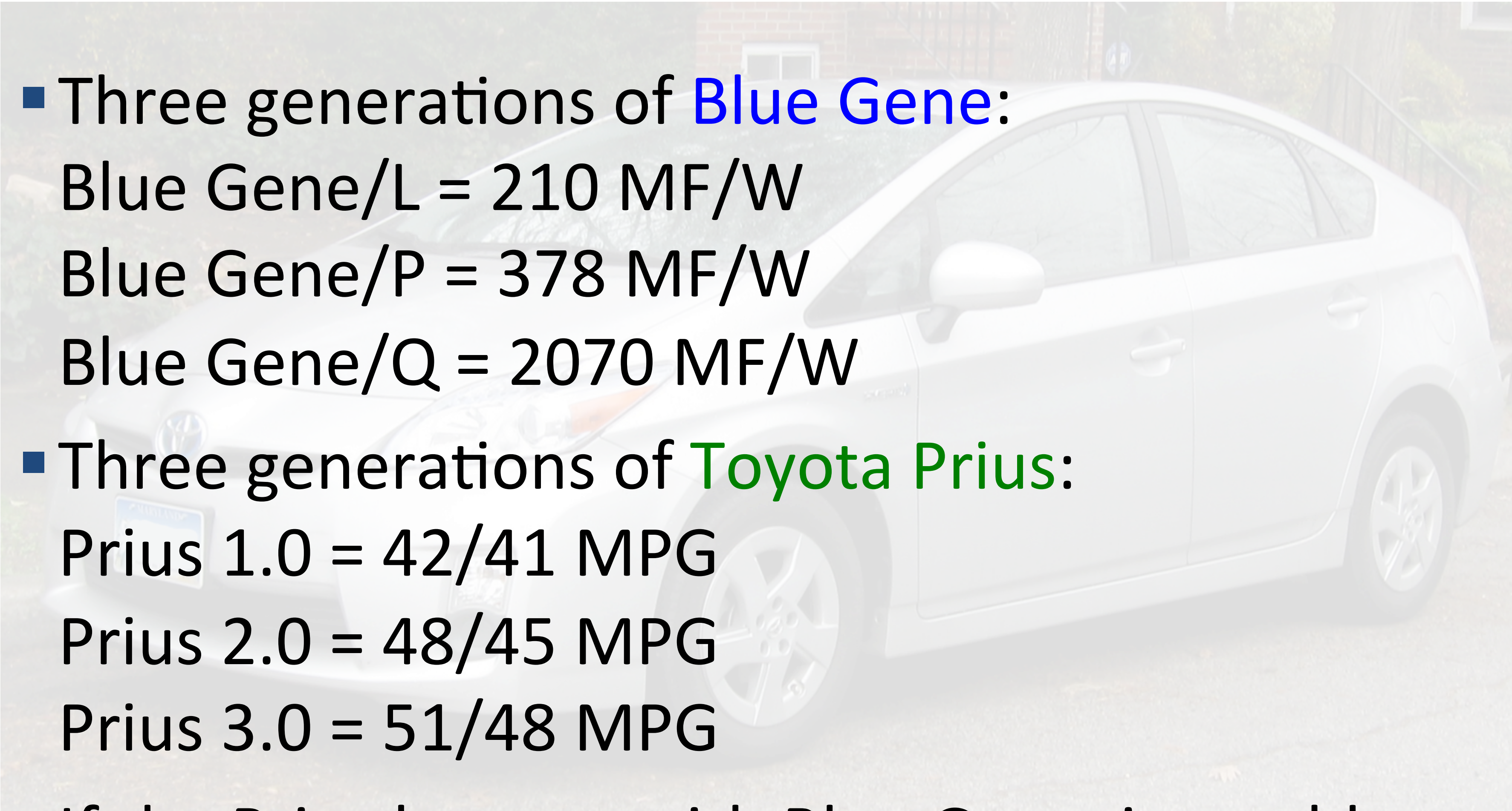
What’s so super about supercomputers?

Efficiency

- Approximately 2% of all the power used in the United States is for data centers. That's ten 1-gigawatt power plants!
- 1 MW per year costs approximately $1,000,000.
- Green500 measures the power efficiency of all known supercomputers in megaflop/s/watt (megaflop/s=1M math operations per second).
- A petaflop supercomputer uses megawatts…



Blue Gene/Q architecture is nearly 3x more efficient than the next best supercomputer (K Machine), saving DOE approximately 6MW and $6M/year!

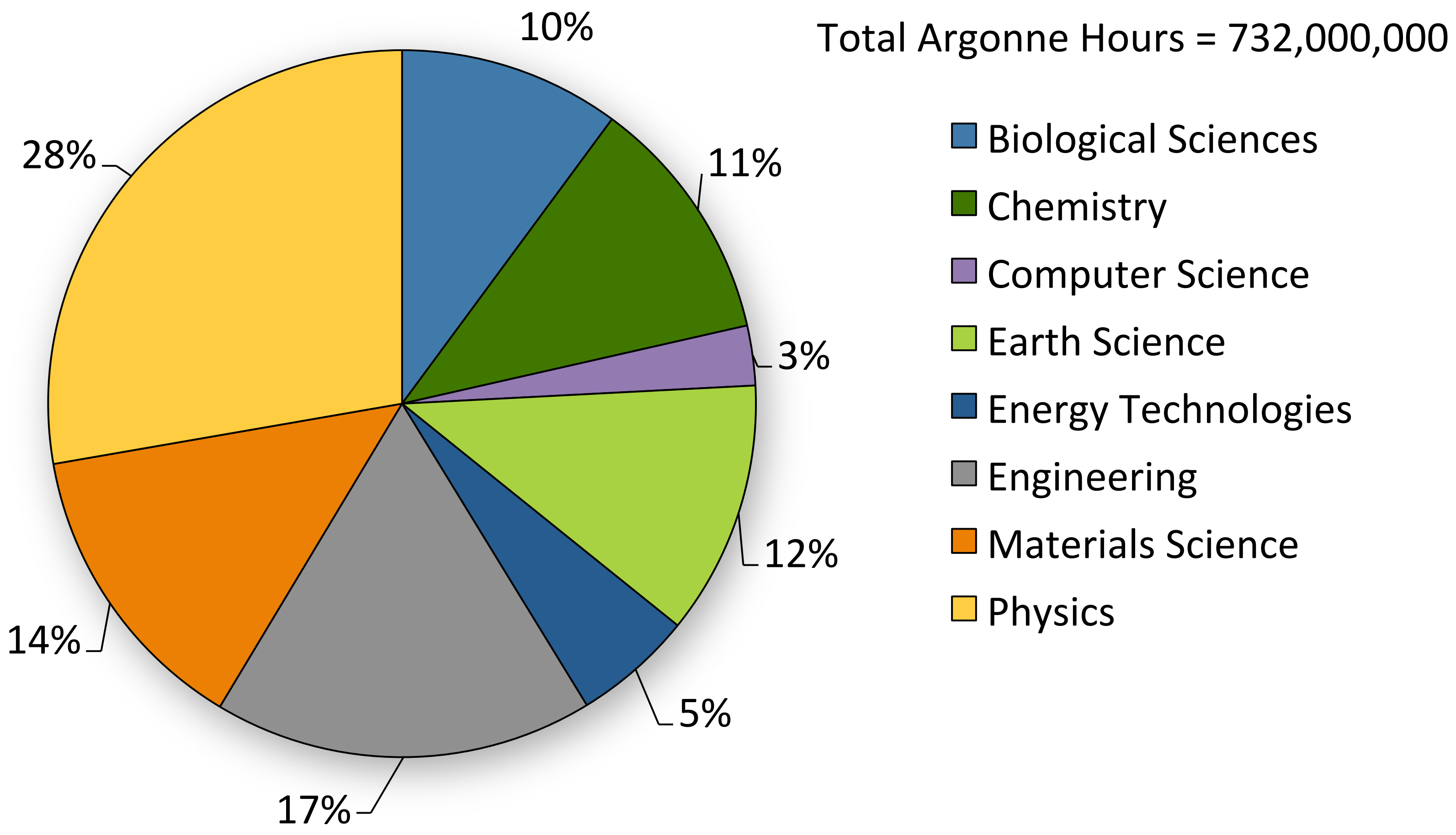


- Three generations of Blue Gene:
  Blue Gene/L = 210 MF/W
  Blue Gene/P = 378 MF/W
  Blue Gene/Q = 2070 MF/W
- Three generations of Toyota Prius:
  Prius 1.0 = 42/41 MPG
  Prius 2.0 = 48/45 MPG
  Prius 3.0 = 51/48 MPG
- If the Prius kept up with Blue Gene, it would achieve 400 miles per gallon!

Science

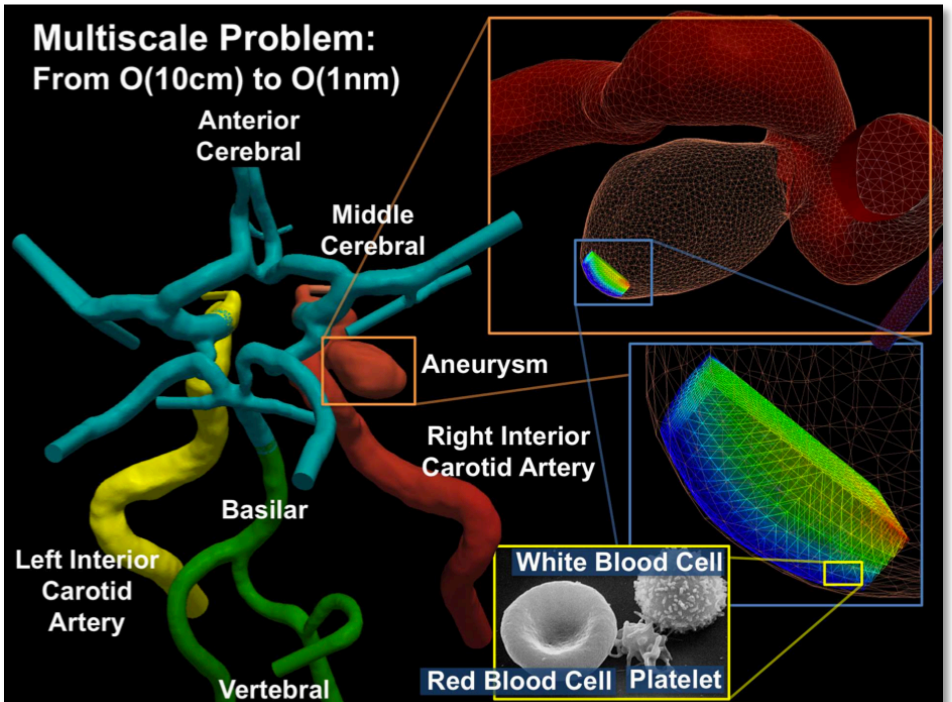
- Supercomputers aren't just bigger…
- A desktop delivers 6000-8000 hours of computing a year.
- Mira will deliver 6,000,000,000 hours of computing a year.
- That's the same ratio as the distance to Madison, WI and the distance to Mars!

2011 INCITE Allocations by Discipline

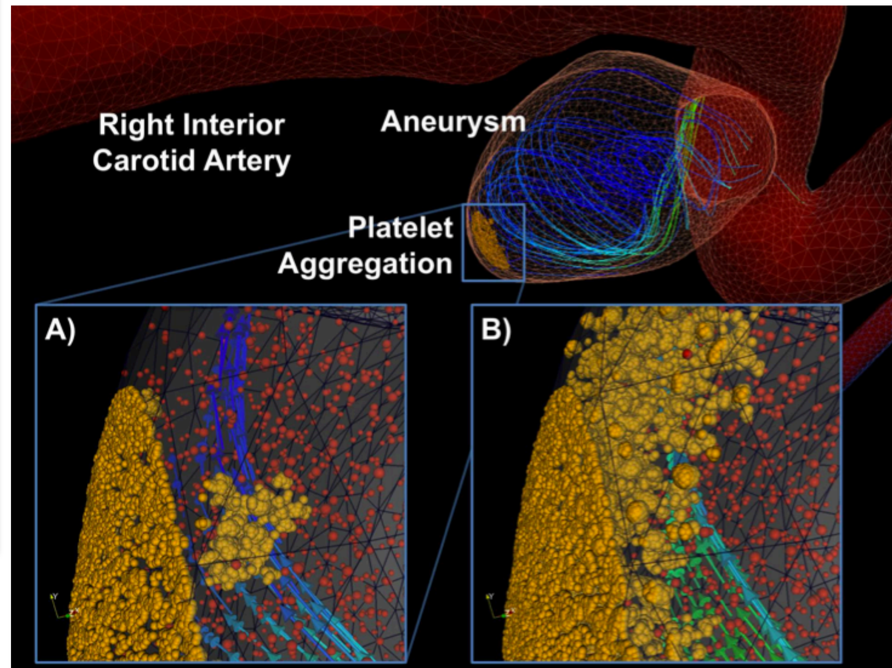


Multiscale Blood Flow Simulations

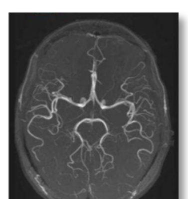
- **Approach:** multiscale simulations of the blood flow in the human brain vasculature: *arteries* (≥ 1 mm), *arterioles* (500-10 μm) and *capillaries* (5 μm).



***Blood**: RBC (45%), WBC (<1%), platelets (1%) and plasma*



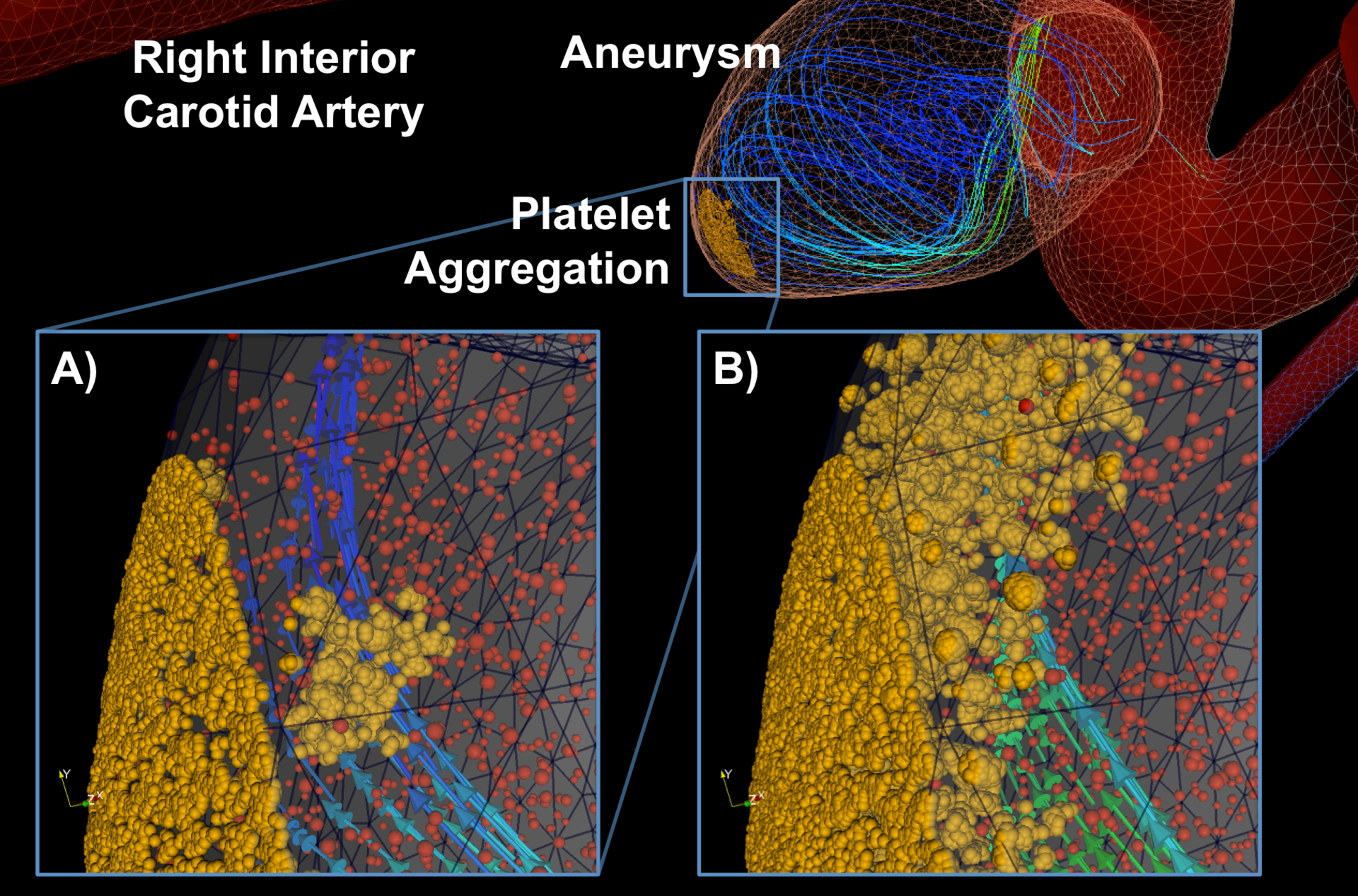
Brain vasculature and aneurysm reconstructed from MRI images



(A-B) Initial stages of clot formation and progress in time and space

Blood Flow: Multi-scale Modeling and Visualization

Leopold Grinberg, George Karniadakis (Brown University), Dmitry A. Fedosov (Forschungszentrum Juelich)
Bruce Caswell (Brown University), Vitali Morozov, Joseph A. Insley, Michael E. Papka, (Argonne National Laboratory)



Multiscale Blood Flow Simulations

Micro-domain: 3.93 mm^3

DPD particles: 823,079,981

Results of a **24-hours simulation** on 32 racks of BG/P = 3.15M hours

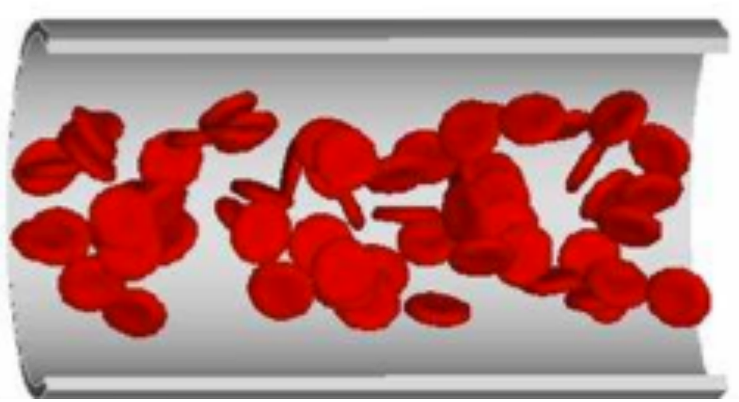
1 day x 80% of BG/P

= 3.15M CPU-hours

≈ 360 days ≈ **1 year** x 1 CPU

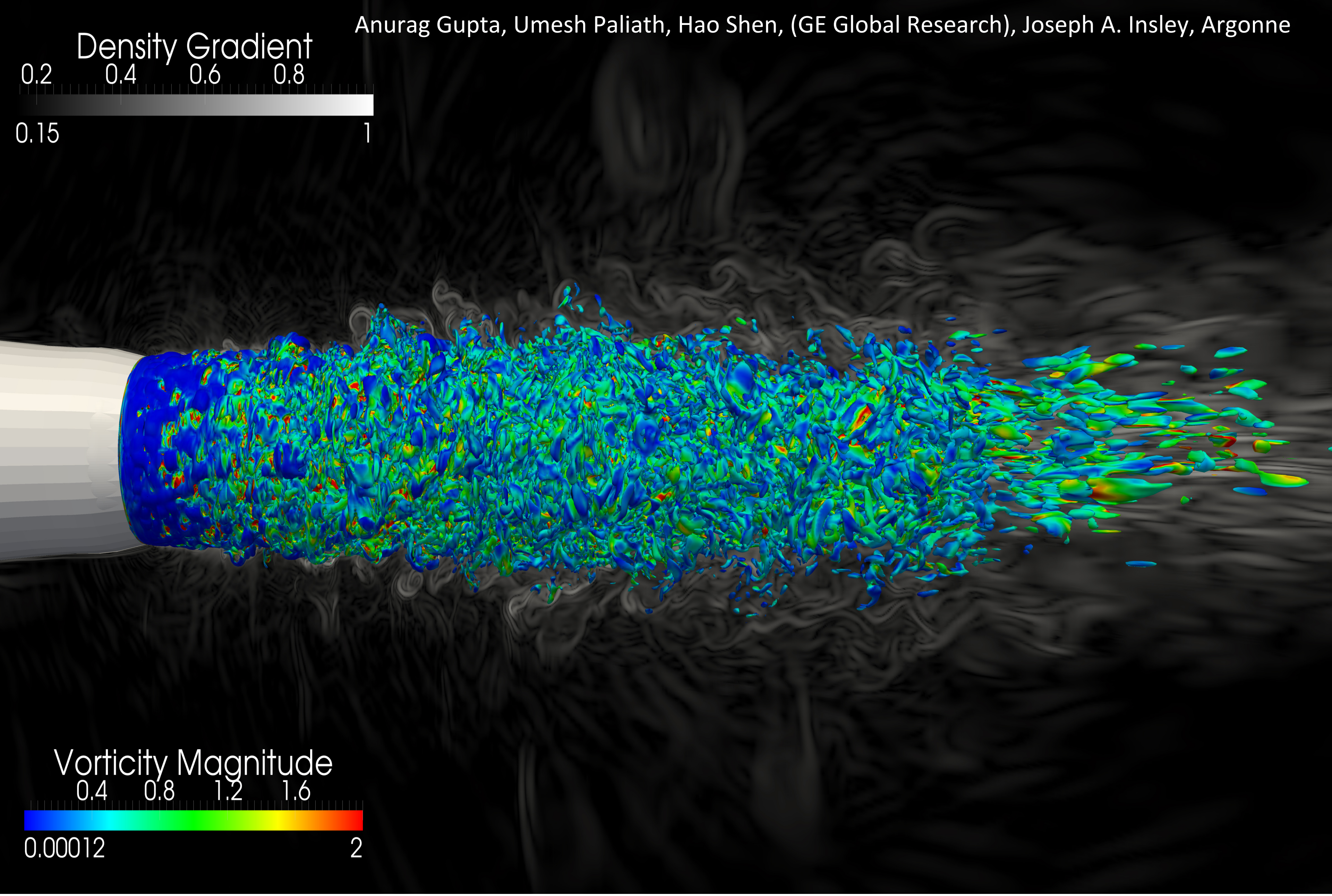
≈ 130,000 iterations

≈ **1/3 of a heart beat**



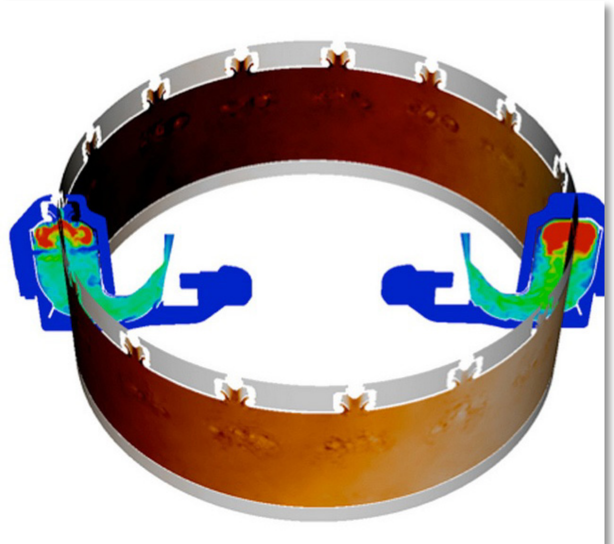
- **Cerebral aneurysms** occur in up to **5%** of the general population, leading to strokes for over **40,000** Americans each year.
- **Sickle cell** (SS) **anemia** (a chronic inflammatory disease) affects **72,000** individuals in USA.
- **Cerebral malaria** (CM) is a red blood cell (RBC) disease, with significant mortality. More than **1.5 Million deaths** each year – mostly in children.

Anurag Gupta, Umesh Paliath, Hao Shen, (GE Global Research), Joseph A. Insley, Argonne

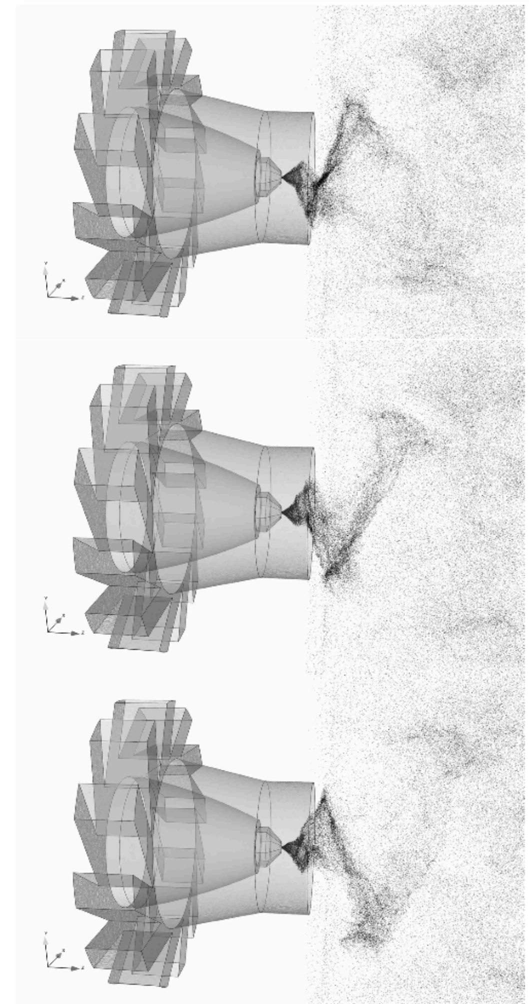


Turbulent Mixing Noise from Jet Exhaust Nozzles

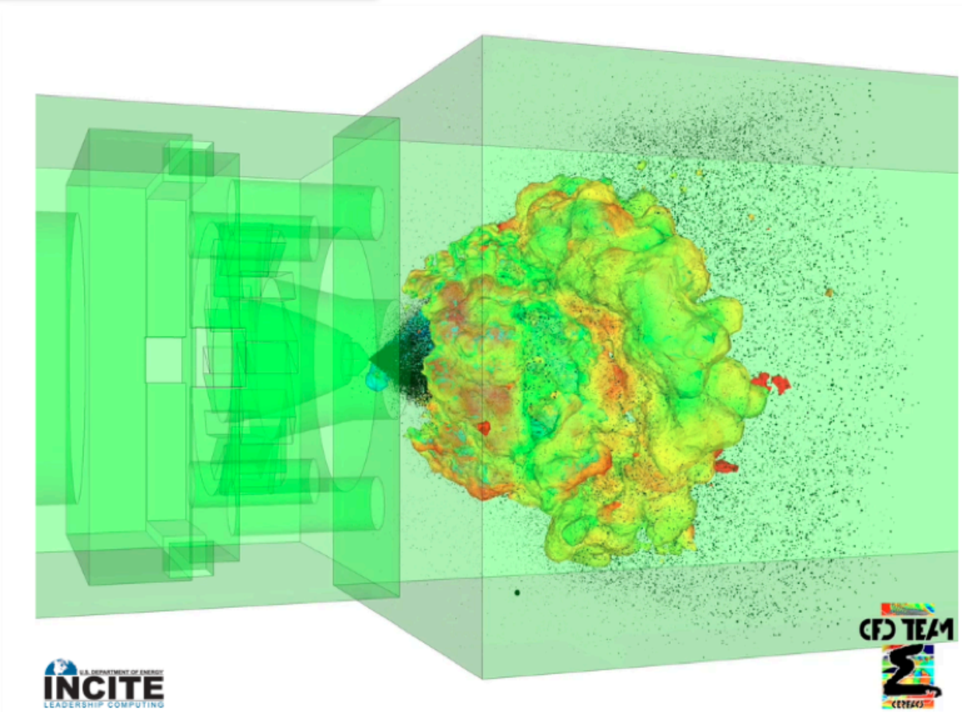
Simulation of Combustion in Gas Turbines

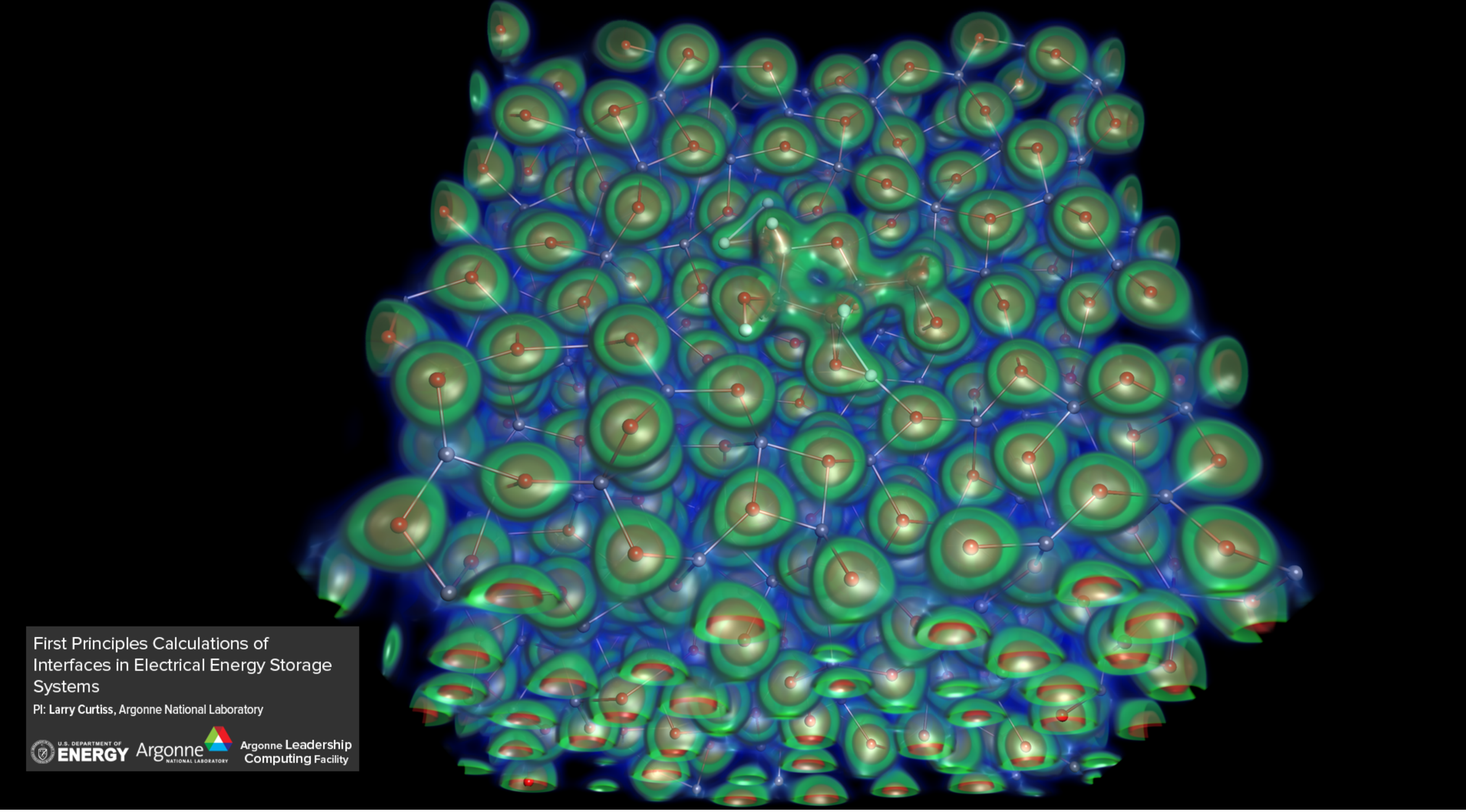


Fields of temperature and pressure in a simulation of a complete helicopter combustion chamber.



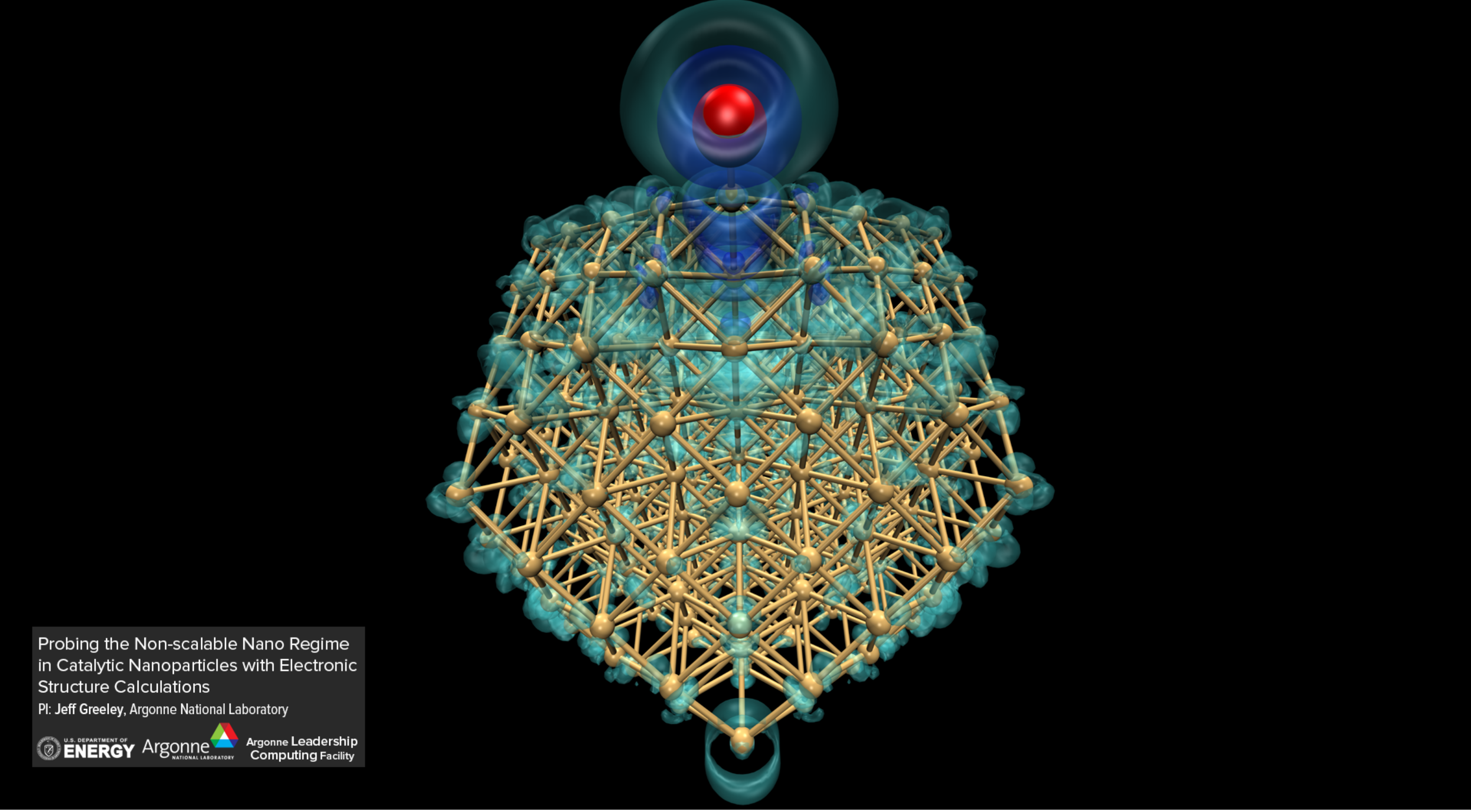
Visualization of the liquid particles with an industrial swirled injector





Efficient energy storage in batteries is critical to the development of cars and other vehicles that don't run on oil.

The important properties of batteries emerge at nanoscale or larger, which is thousands of atoms.



Quantum mechanical simulations requires enormous amounts of memory, more memory than all the hard drives in your house.

Accurate modeling of catalytic properties of nanoparticles can't be done with less than a supercomputer.