



**BERKELEY LAB**

Bringing Science Solutions to the World



U.S. DEPARTMENT OF  
**ENERGY**

Office of Science

# NERSC

## National Energy Research Scientific Computing Center

**NERSC**

Richard Gerber  
NERSC Senior Science Advisor  
High Performance Department Head



**BERKELEY LAB**

Bringing Science Solutions to the World

Office Floors and  
Main Entrance

Computer Room

Mechanical Area



Office of Science

**Shyh Wang Hall**  
Building 59

# Today's Tour



The mission of the National Energy Research Scientific Computing Center (NERSC) is to accelerate scientific discovery at the DOE Office of Science through high performance computing and data analysis.



ESnet's Mission is to enable and accelerate scientific discovery by delivering unparalleled network infrastructure, capabilities, and tools.



## Wang Hall Residents



Computational  
Research Divisions

Applied Math &  
Computational Rsch  
Scientific Data



ESnet



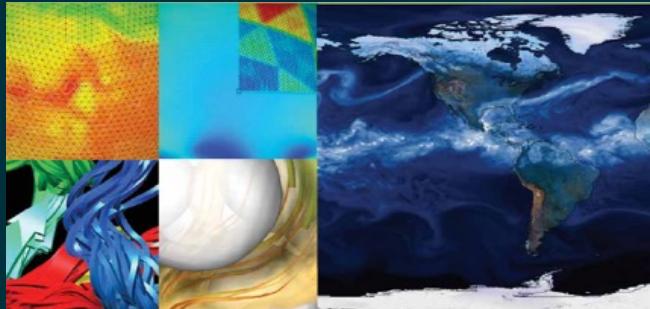
NERSC

# NERSC & ESnet: Mission High Performance Computing, Data, & Networking For the DOE Office of Science



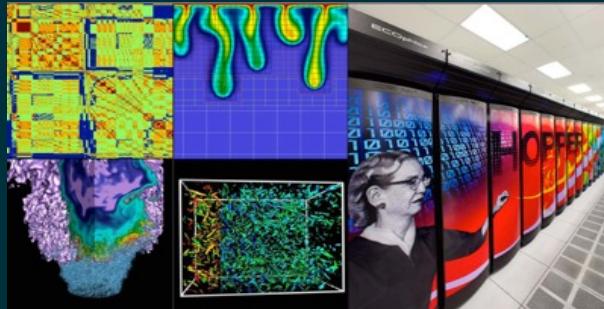
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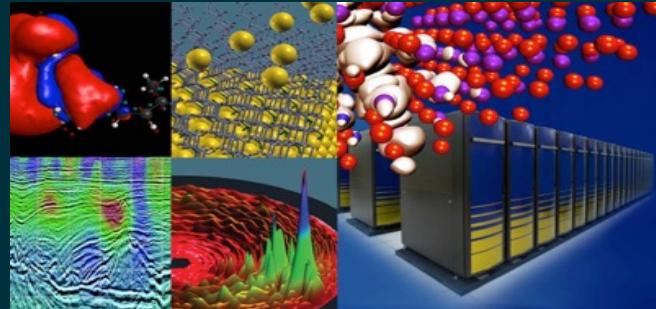


Bio Energy, Environment

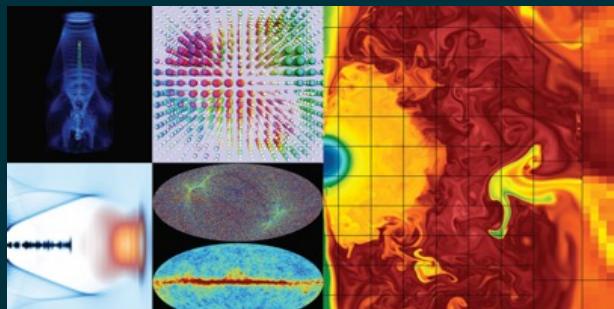
Largest funder of physical science research in the U.S.  
Unclassified fundamental science and engineering



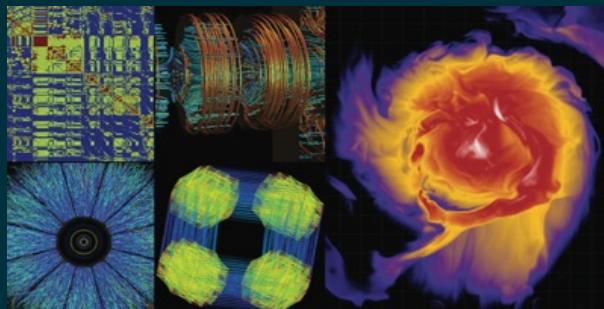
Advanced Computing



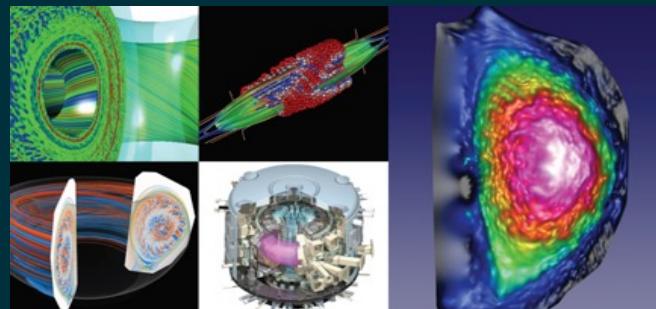
Materials, Chemistry, Geophysics



Particle Physics, Astrophysics



Nuclear Physics



Fusion Energy, Plasma Physics

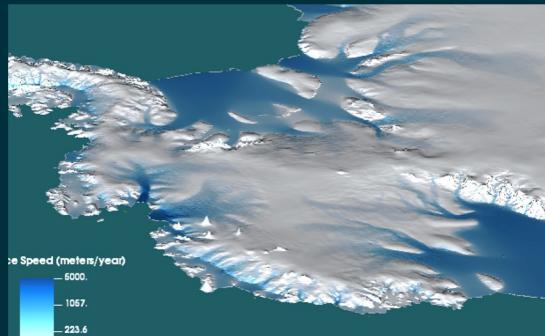
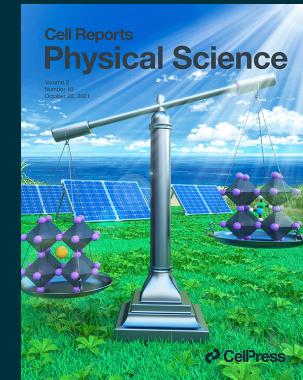
# NERSC's Users Produce Groundbreaking Science



## New Materials for More Efficient Solar Cells

New study reveals the promise of using all-inorganic perovskite materials for solar energy conversion.

*Cell Reports Physical Science*



## Machine Learning Technique Adds Depth, Breadth & Speed for Sky Survey Analysis

Self-supervised representation learning overcomes shortcomings of existing methods for enabling discovery.

*Astrophysical Journal Letters*

## Land Ice Contributions to 21<sup>st</sup> Century Sea Level Rise

Scientists quantify the effect of melting land ice on the global sea level.

*Nature*



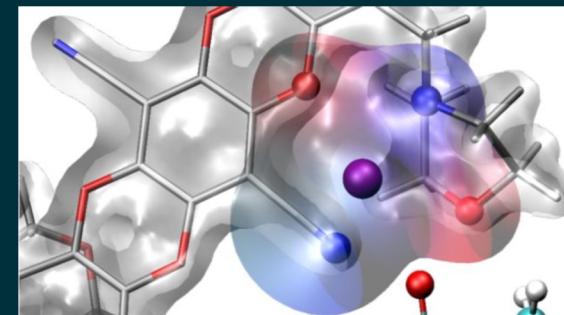
## Climate & Extreme Weather

NERSC is a hub for climate and extreme weather research and the impacts on diverse communities.



## World Most Advanced Coupled Earthquake-Building Simulations

Public planners can now access advanced models of different earthquake rupture scenarios will affect the public through an open-access database.



## Breakthrough in Efficiency of Membranes for Batteries, Fuel Cells and Water Purification

Researchers have designed a membrane with "solvation cages" that can greatly speed up the flow of the desired molecules through an interface.

*Nature*

# Perlmutter

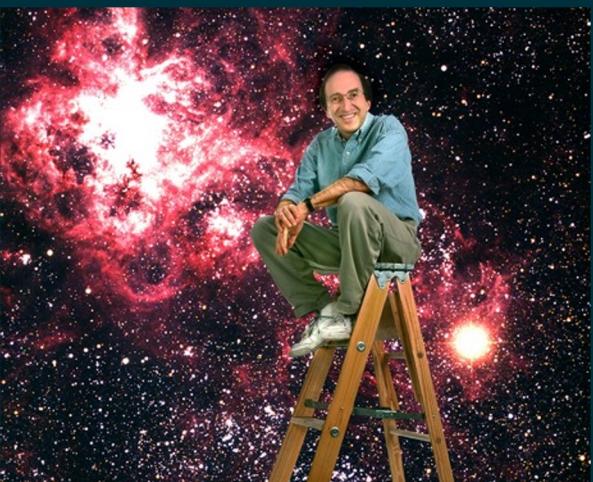


NERSC's newest supercomputer is a Cray "Shasta" system that debuted as the 5<sup>th</sup> most powerful supercomputer in the world in 2021 (currently #8)

Designed to meet needs of large-scale simulation, data analysis, & AI/Learning

Includes both NVIDIA GPU-accelerated and AMD CPU-only nodes

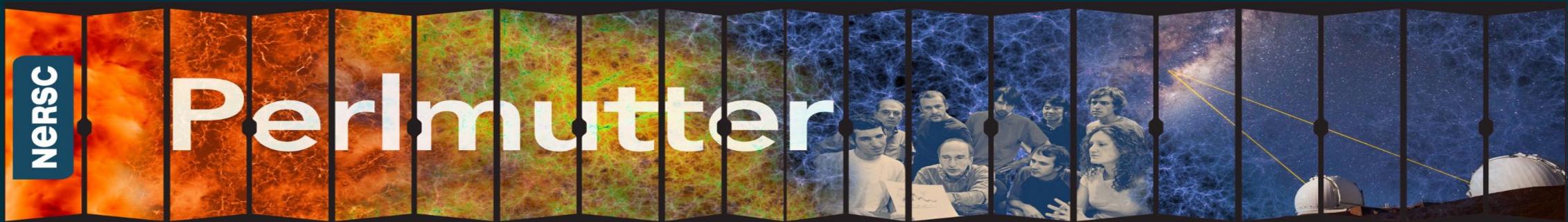
35 PB All-Flash filesystem



Named after Nobel Prize Winning Berkeley Lab Scientist – and NERSC user - Saul Perlmutter

Co-discovered the accelerating expansion of the Universe ("Dark Energy")

# Perlmutter: Optimized for Science



- HPE Cray System with ~4x capability of Cori
- GPU-accelerated and CPU-only nodes
- HPE Cray Slingshot high-performance network
- All-Flash filesystem
- Application readiness program (NESAP)

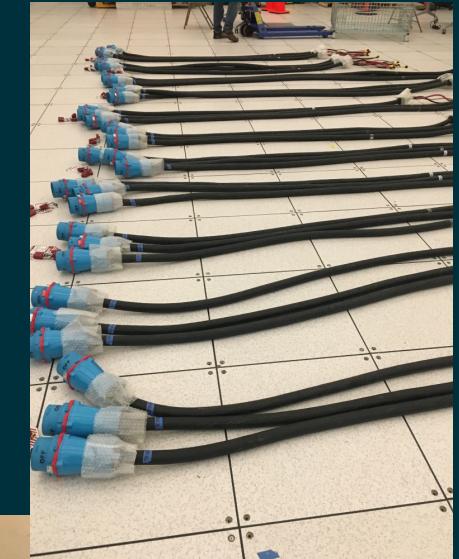
## Phase 1

- 1,792 GPU-accelerated nodes
- 1 AMD “Milan” CPU + 4 NVIDIA A100 GPUs per node
- 256 GB CPU memory and 40 GB GPU high BW memory
- 35 PB FLASH scratch file system
- User access and system management nodes

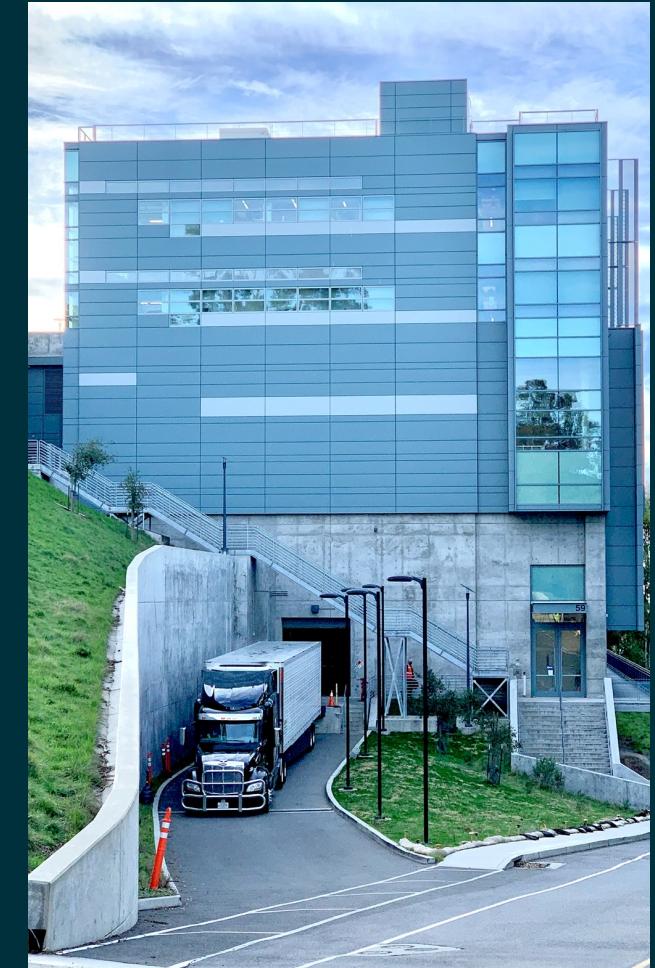
## Phase 2

- 3,072 CPU only nodes
- 2 AMD “Milan” CPUs per node
- 512 GB memory per node
- Upgraded high speed network: Slingshot 11
- CPU partition will match or exceed performance of the entire Cori

# It's a Lot of Work to Set Up and Test a New System at this Scale



# Perlmutter Phase I Arrived on February 22, 2021

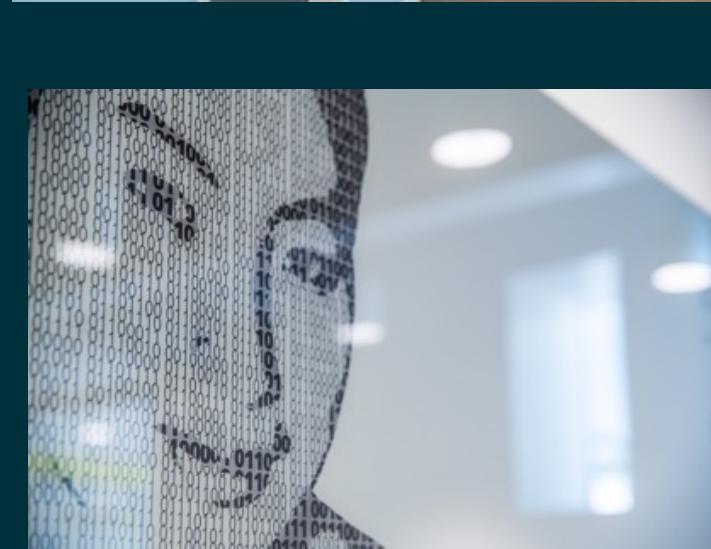


# Dr. Perlmutter Started the First Science Runs

# Welcome to Shyh Wang Hall



# We Enter on the Office Floors at the Top of the Building



# And Descend to the Computer Room Underneath



# The First You'll See is the Control Room





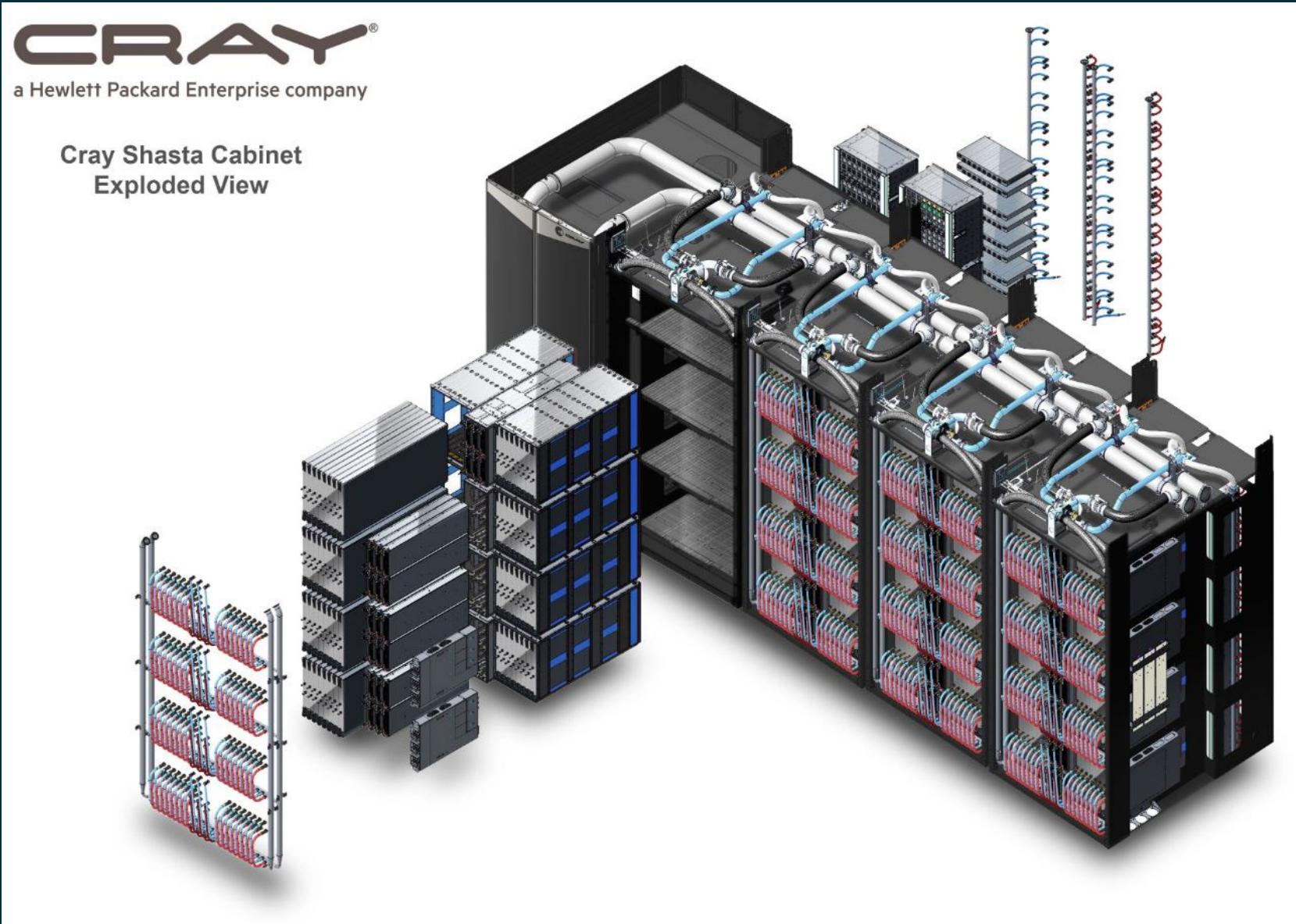
# Inside Perlmutter

CPU Compute Blade – 4 nodes (8 CPUs)



Blades in a rack with hot (red) and cold (blue) liquid cooling tubes

# Perlmutter Cabinets



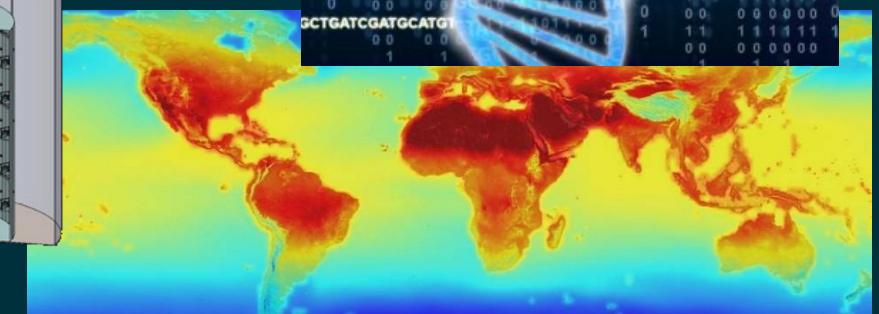
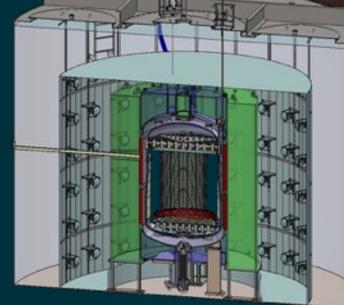
# NERSC is a Big Data Center



~250 PB of  
Archival  
Storage

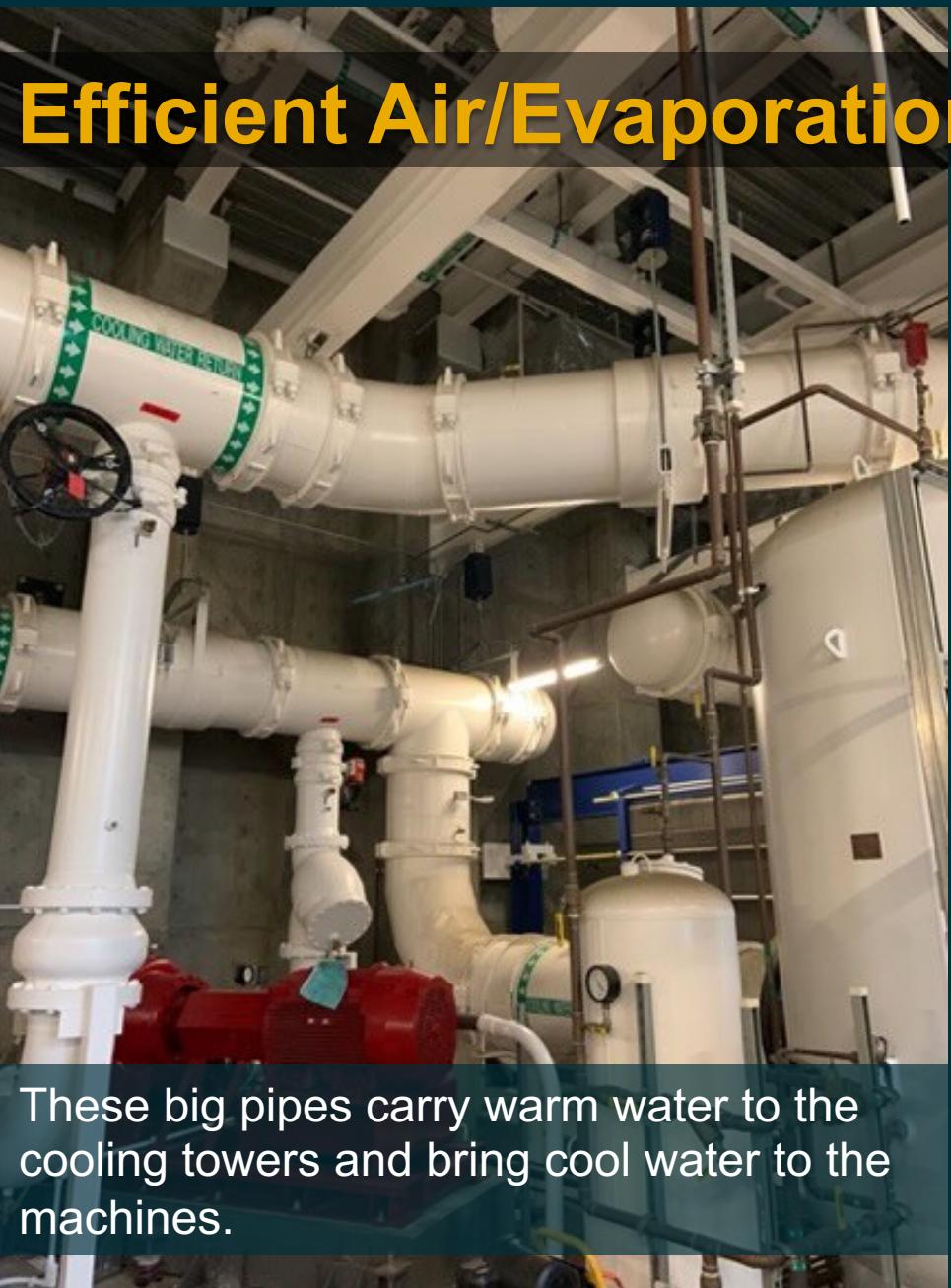


~120 PB of disk  
storage in  
Community File  
System



# Mechanical Area Below





These big pipes carry warm water to the cooling towers and bring cool water to the machines.





# Perlmutter

Accelerating Scientific  
Discovery through HPC

Thursday, May 27  
10:30am – 11:45am PT

NERSC

National Energy Research  
Scientific Computing Center  
(NERSC)



UNIVERSITY  
OF  
CALIFORNIA

# NERSC by the Numbers

NERSC BY THE NUMBERS

**>7,000 ANNUAL USERS FROM ~1,700 Institutions + National Labs**



**34%**  
Graduate  
Students



**22%**  
Postdoctoral  
Fellows



**18%**  
Staff  
Scientists



**12%**  
University  
Faculty



**7%**  
Undergraduate  
Students



**7%**  
Professional  
Staff



**29% DOE Labs**  
**5% Other Government Labs**



**2% Industry**



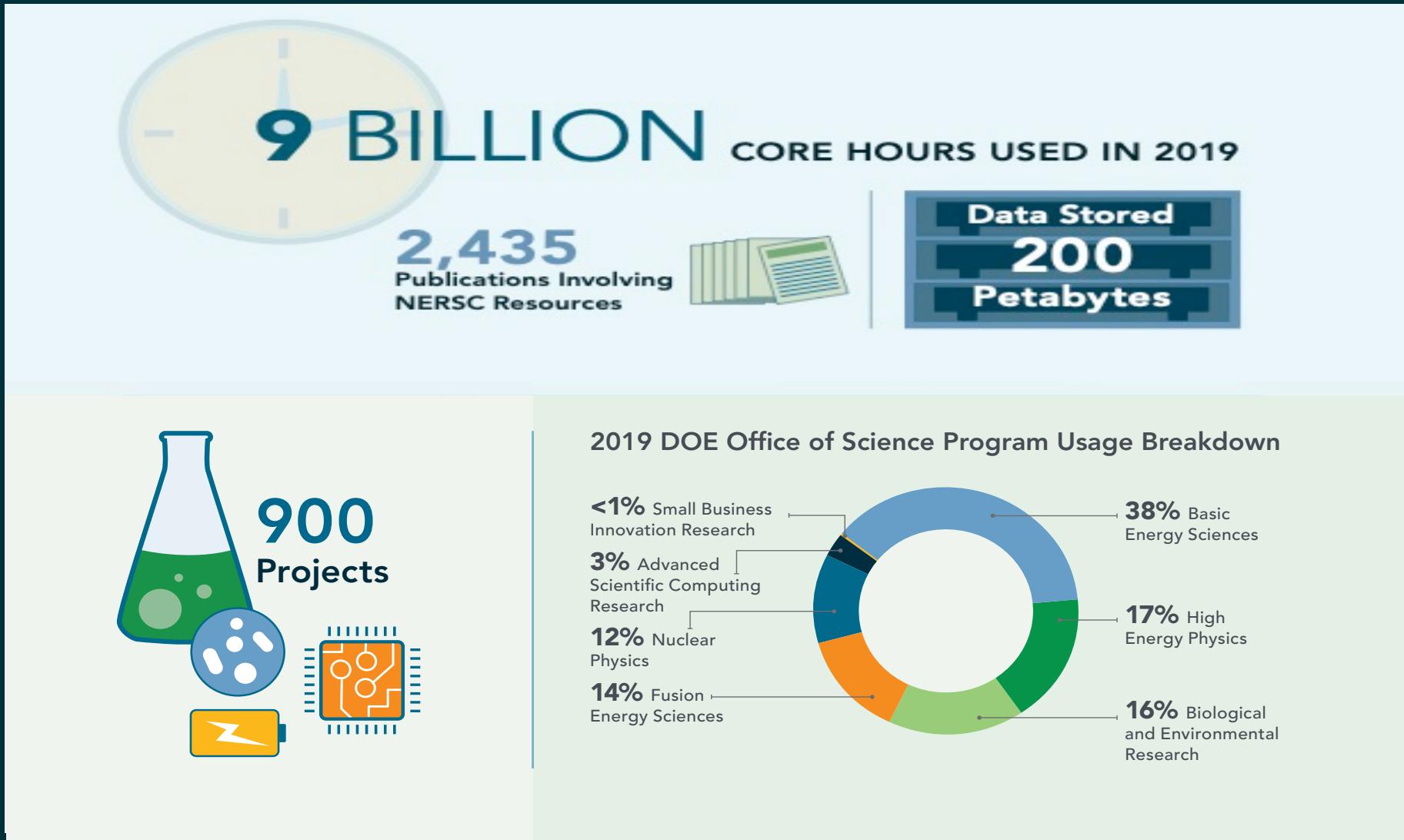
**1% Small  
Businesses**



**<1% Private Labs**



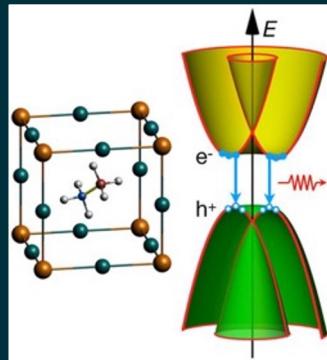
# NERSC by the Numbers



# What Are NERSC Supercomputers Used For?

## Revealing Mechanisms for Solar Cells

Researchers from UC Santa Barbara are better understanding the solar conversion efficiencies of hybrid perovskites and gaining critical insights into how they work.



## Constraints on the Size of Neutron Stars

Scientists have determined with unprecedented accuracy that a neutron star with 1.4 times the mass of our Sun is packed into a sphere 11.75 km in radius.



## Energy Storage

Scientists from UC San Diego developed a new material that makes batteries safer, holds more charge and charges faster.



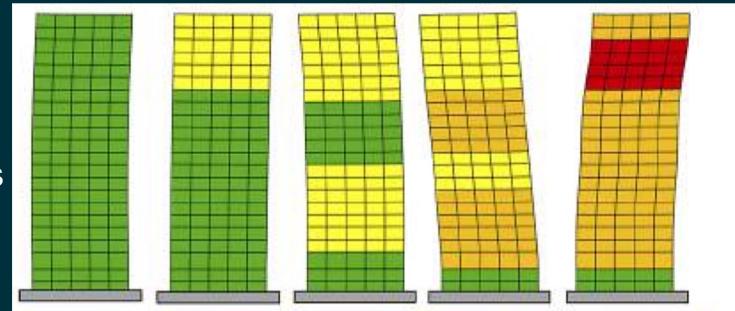
## Rocket Thruster Could Propel Humans to Mars and Beyond

The proposed device can generate exhaust with velocities of hundreds of kilometers per second.



## Regional Simulations of Building Response to Major Earthquakes

The study looked at many scenarios of interest to inform civic planners so they can save lives and protect infrastructure.



## Urban Landscapes Boost Destructive Storms

A team from Pacific NW Lab found that urban landscapes and pollution can make wind gusts stronger, rain heavier, hail larger and even steer storms toward cities.

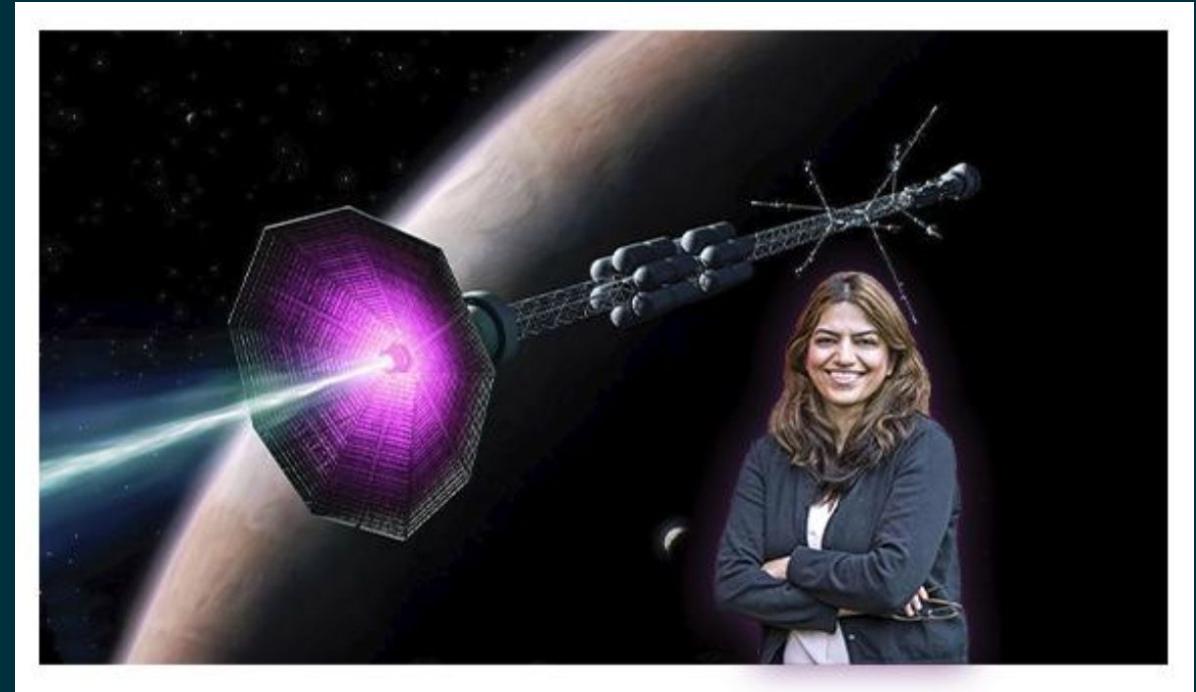


# New Rocket Could Propel Humans to Mars and Beyond

A scientist at Princeton Plasma Physics has proposed a new type of rocket thruster that could take humankind to Mars and beyond, based on calculations performed on NERSC's Cori supercomputer.

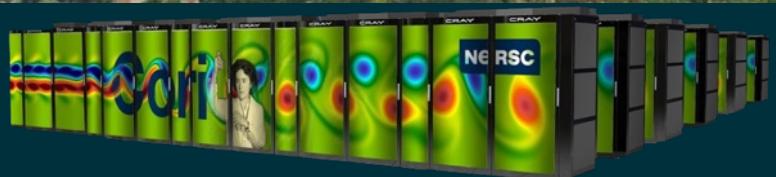
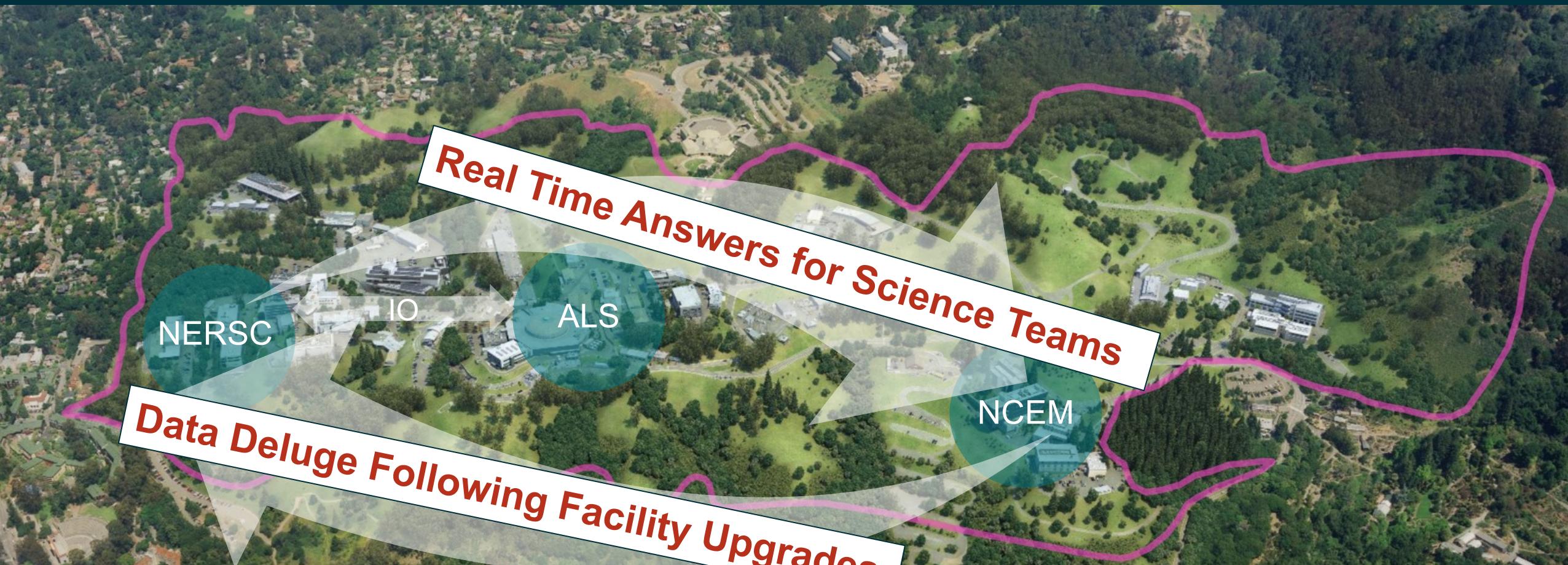
Fatima Ebrahimi showed that the new plasma thruster concept can generate exhaust with velocities of hundreds of kilometers per second, 10 times faster than those of other thrusters.

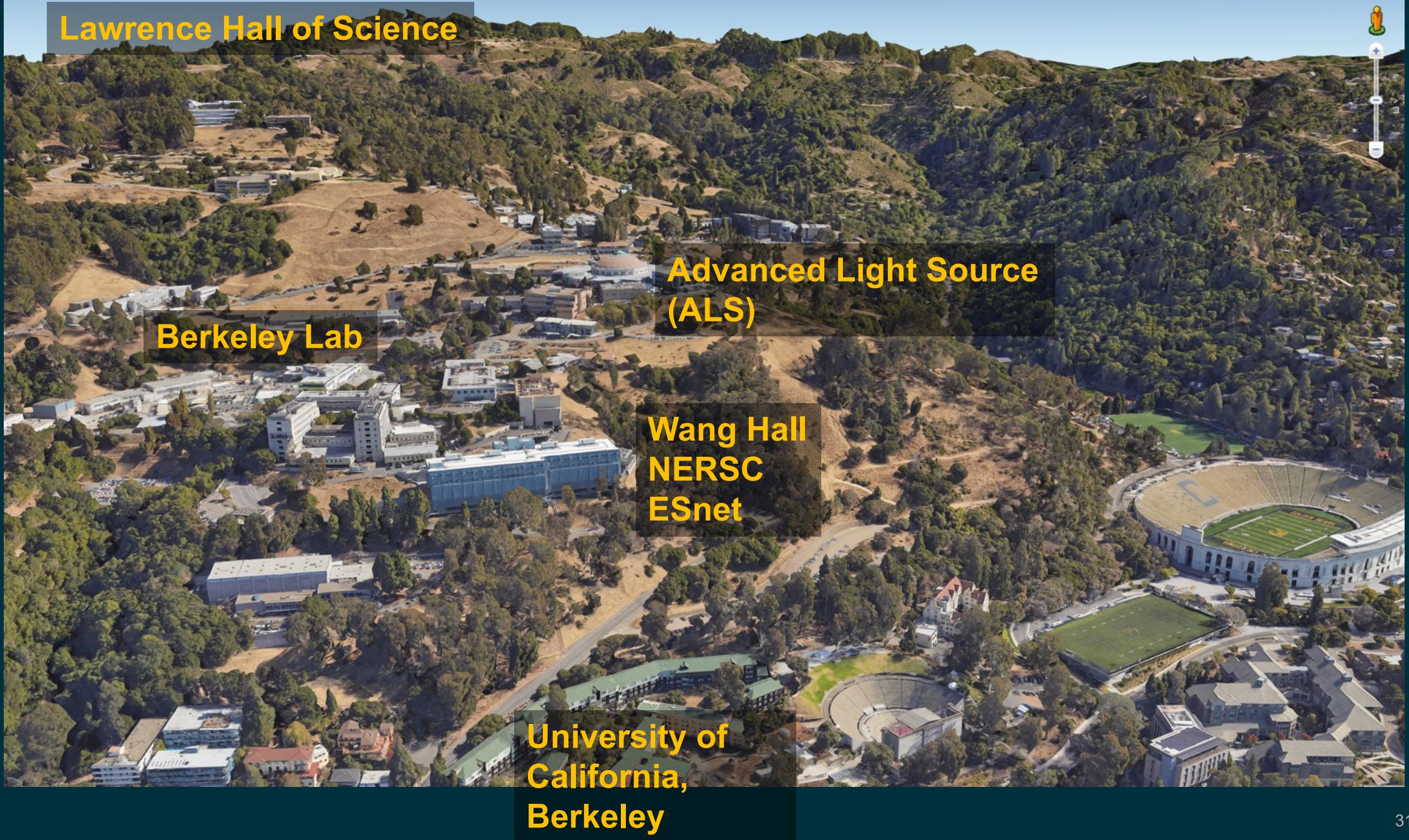
That faster velocity at the beginning of a spacecraft's journey could bring the outer planets within reach of astronauts, turning years of travel to months.



Princeton physicist Fatima Ebrahimi stands in front of an artist's conception of a rocket powered by plasma exhaust. The energetic plasma is created through magnetic reconnection, a process that occurs in the Sun and in fusion reactors.

# NERSC is Teaming with Experimental Facilities







# First Scientific Jobs

The screenshot shows a web browser window displaying the Perlmutter Dedicated cluster's landing page. The header features a large banner with the NERSC logo and the word "Perlmutter" in white, overlaid on a background of scientific visualizations. Below the banner, the text "Now Computing on Perlmutter" is displayed. The main content area lists five scientific projects, each with a small thumbnail image, the project name, and the researcher's name and affiliation.

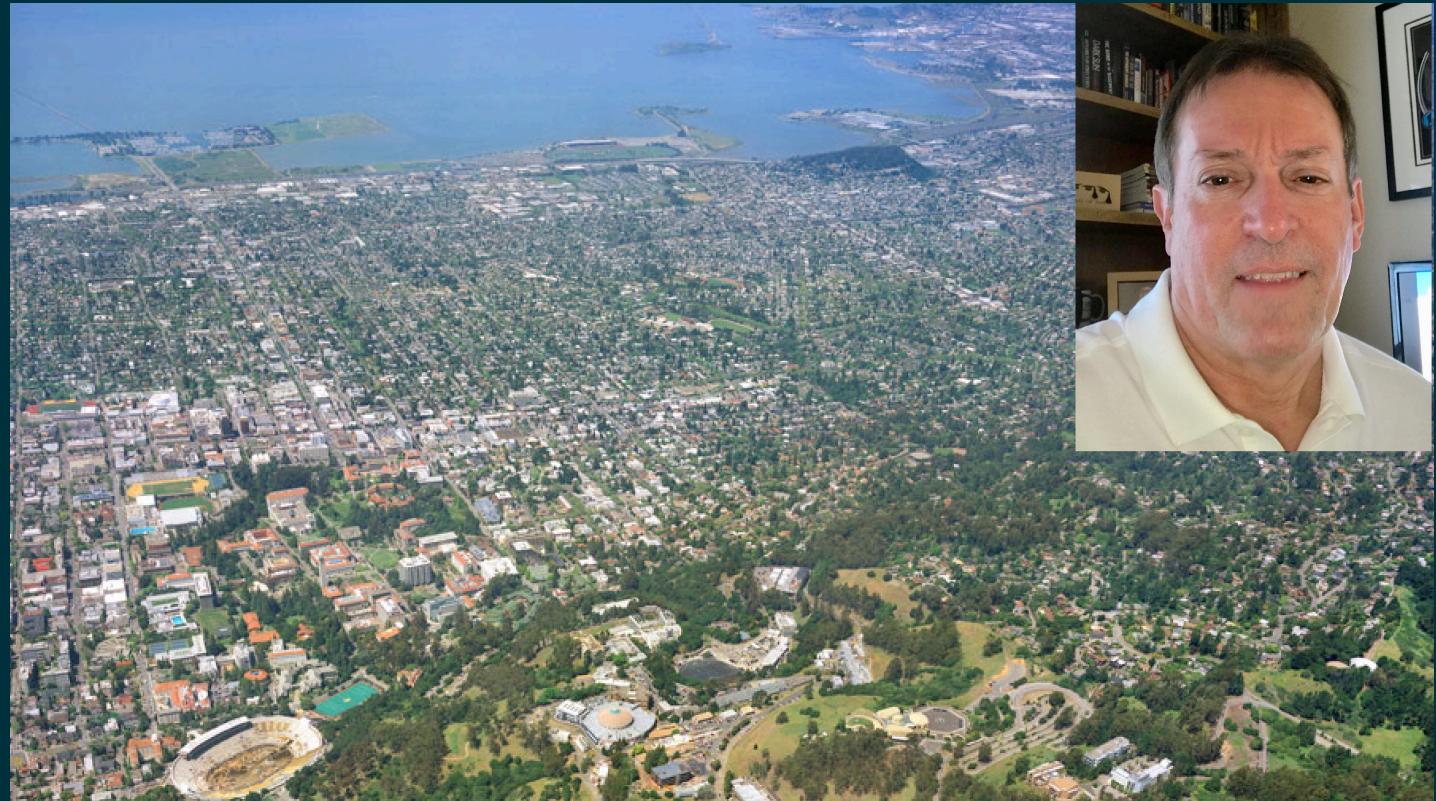
Project	Researcher(s)	Affiliation
Catalysts for Environmentally Benign Energy Production	M Mavrikakis	U of Wisconsin - Madison
Lattice QCD Search for Physics Beyond the Standard Model	R Gupta	Los Alamos National Laboratory
Deep Learning for Discovery of New Catalyst Materials	Z Ulissi	Carnegie Mellon
Simulations in Joint Center for Artificial Photosynthesis	L Wang	Berkeley Lab
Deep Learning Assisted Simulation of Computational Fluid Dynamics	M Day	National Renewable Energy Laboratory

At the bottom left, there is a link to "NERSC-welcome.png". At the bottom right, there are "Show All" and "X" buttons.

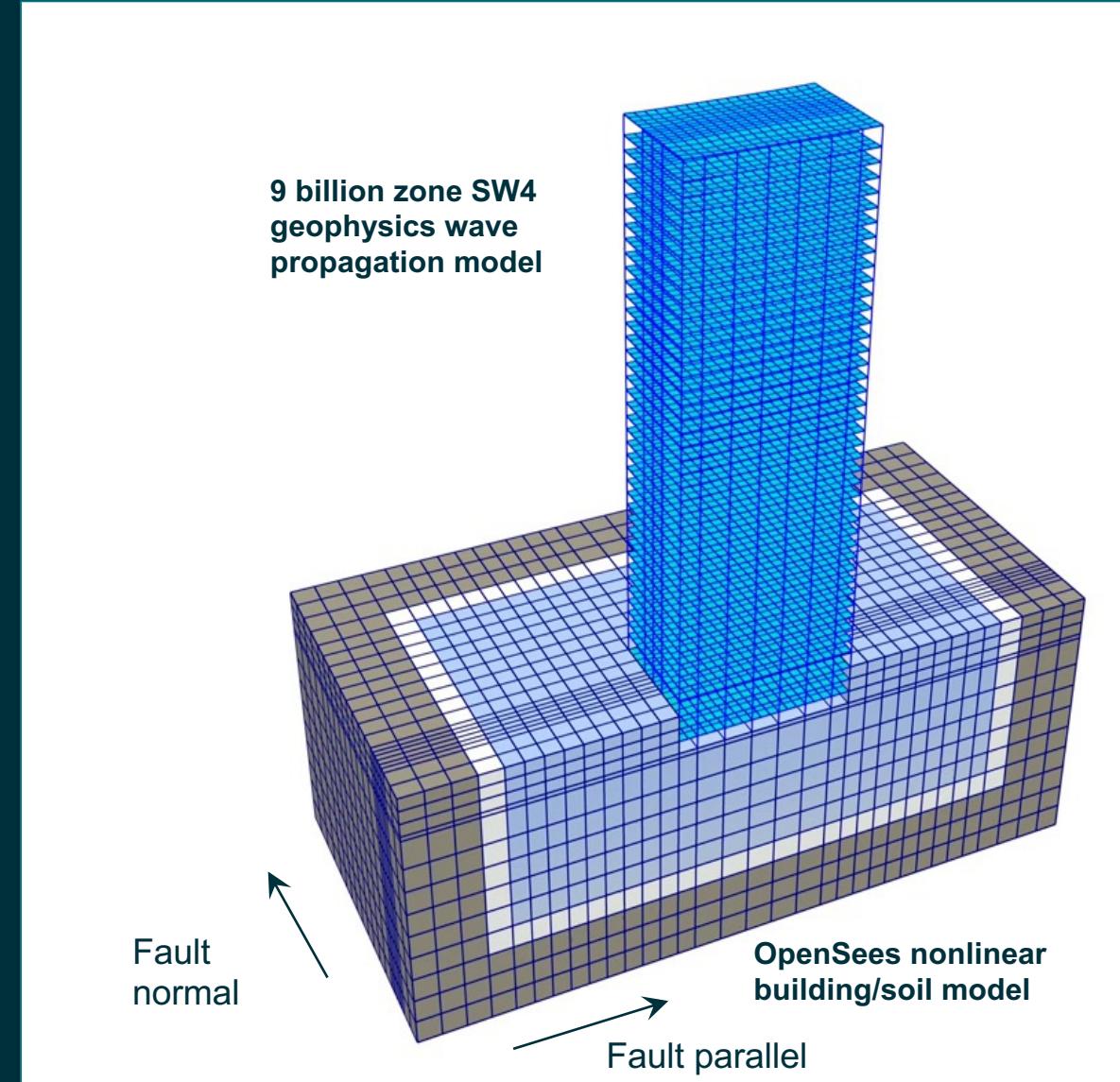
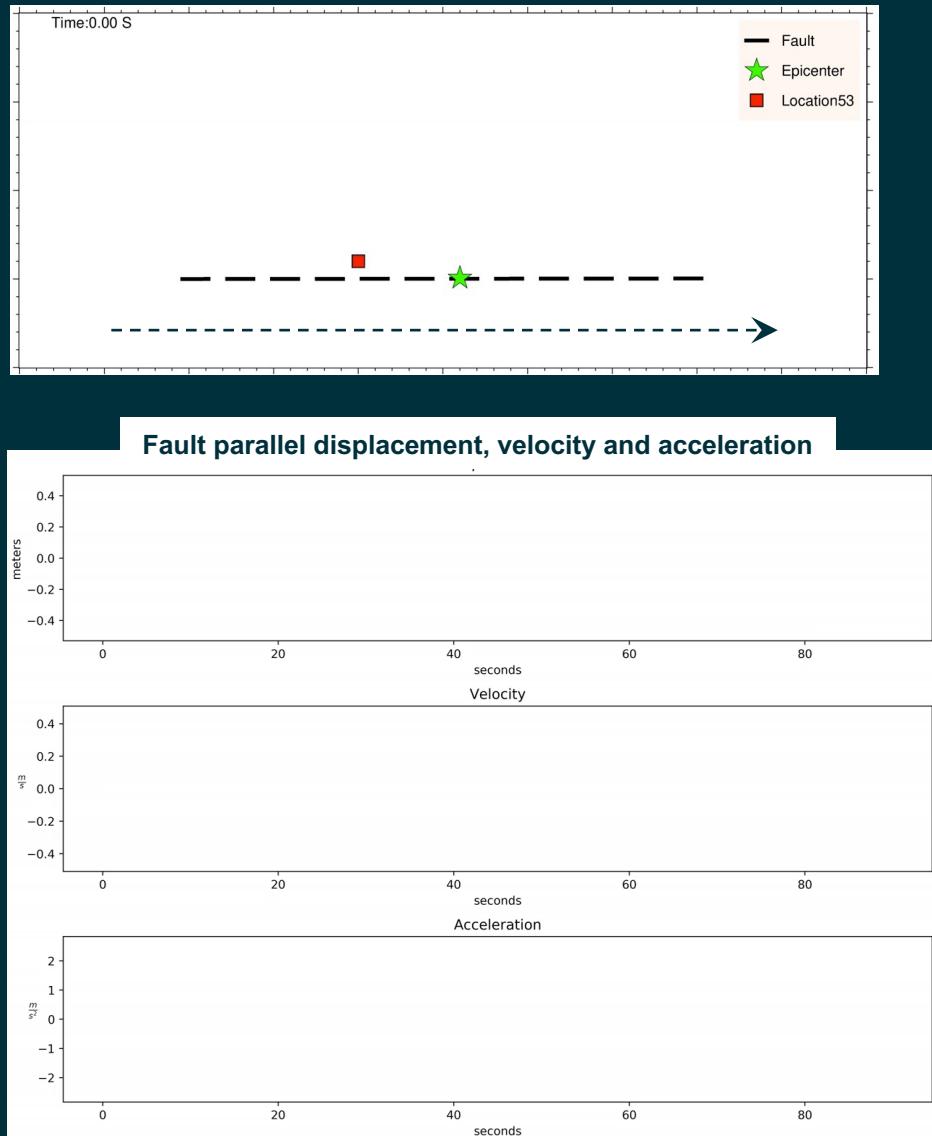
# Earthquake Risk

David McCallen  
University of Nevada-Reno  
Berkeley Lab

EQSIM—A multidisciplinary framework  
for fault-to-structure earthquake  
simulations on exascale computers,  
part II: **Regional simulations of building**  
**response**



# 40 story building response at location 53 (2km off the fault)

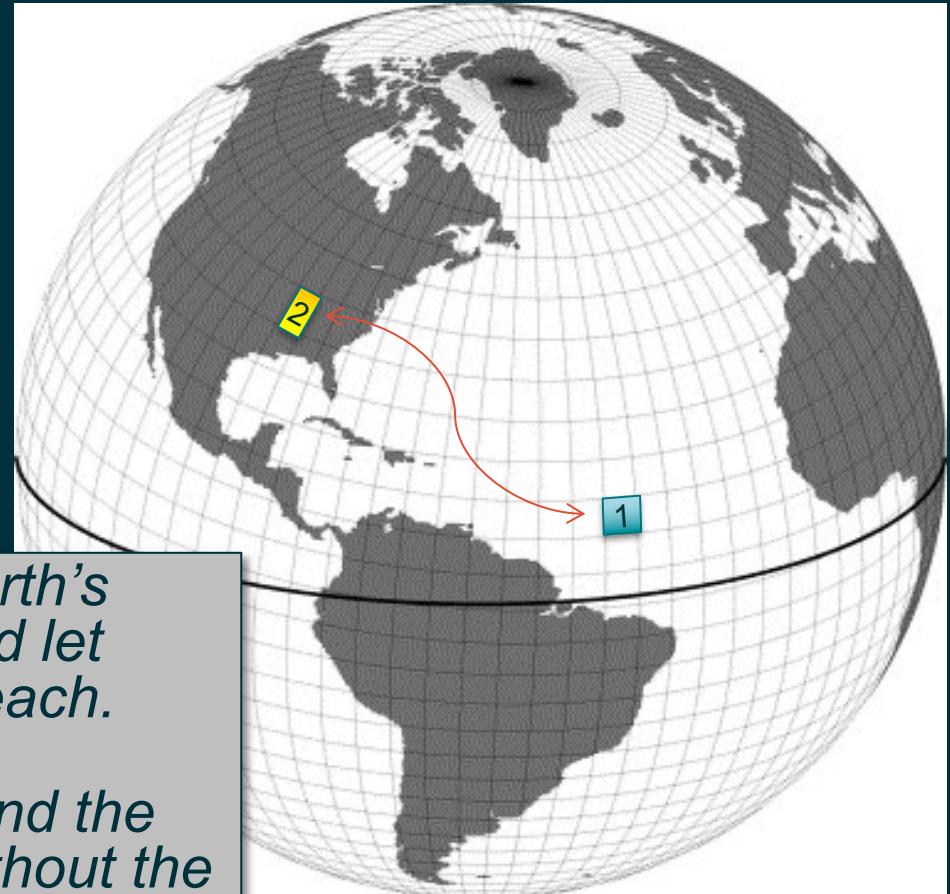


# How Do All Those Processors Work Together?

- Divide a big task into smaller ones
- Each processor works on its piece
- Sends results to other processors
- Repeat until complete

*For example, to simulate the behavior of Earth's atmosphere, you can divide it into zones and let each processor calculate what happens in each.*

*From time to time each processor has to send the results of its calculation to its neighbors. Without the high-speed custom network available on supercomputers, this communication step would make the calculations take much too long.*



Processors 1 and 2 work on different parts of the problem, then send results to other processors that need the data

# Let's Take a Look Around the Computer Room

