

November 16, 2021

Big Ideas

WITH MICHAEL E. PAPKA

DATA, DEVICES AND INTERACTION LABORATORY



Northern Illinois
University

WHAT IS A BIG IDEAS CLASS?

- ▶ Lectures and discussions of current research and technical developments in computer science for beginning graduate research students. Topics will emphasize open problems and recent scientific advances. Content may vary to reflect research advances in areas such as data analytics, scientific computing, graphics and visualization.



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- Who has active research projects?
- What are NIU CS faculty interests?
- Where do I get more information?
- How do I get involved?

BIT ABOUT ME (EDUCATION)

- ▶ Northern Illinois University - Physics (BS)
- ▶ University of Illinois @ Chicago - Computer Science (MS)
- ▶ University of Chicago - Computer Science (MS, PhD)
- ▶ Continuously learning in other areas
 - ▶ University of Chicago - Business School (SLLP)
 - ▶ Harvard University - Business School (GMP)
 - ▶ Stanford University - Hasso Plattner Institute of Design (Design Thinking)

BIT ABOUT ME (CAREER)

- ▶ Fermi National Accelerator Laboratory (Undergraduate/Graduate Student)
- ▶ Argonne National Laboratory (Deputy Associate Laboratory Director, Division Director, Senior Scientist)
- ▶ University of Chicago (Senior Fellow)
- ▶ Illinois Institute of Technology (Research Professor)
- ▶ Northern Illinois University (Presidential Research, Scholarship, and Artistry Professor)

BIT ABOUT ME (RESEARCH)

- ▶ Advanced Display Environments and Collaboration Technology
- ▶ High Performance Computing (Systems and Environments)
- ▶ Internet of Things (Computing Continuum) [Edge Computing]
- ▶ Information and Scientific Visualization
- ▶ Data Analysis
- ▶ Augmented/Virtual Reality

BIT ABOUT THE ddiLAB

- ▶ Joint with **School of Art and Design** and co-directed with Professor Joseph Insley (Time Arts)
- ▶ Focused on **visualization** and **data analysis** coupled to **high-performance computing** in the support of **science**, with side efforts involving the *Internet of Things* (edge computing) and interdisciplinary activities connected to computing
- ▶ Students
 - ▶ 1 PhD (Information Visualization)
 - ▶ 8 Undergraduates (IoT, VR, and HPC)

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We are looking
to hire MS and
PhD students!!!

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SUPERCOMPUTERS



Cray X-MP/4 supercomputer, 1985
www.computerhistory.org/revolution/supercomputers/10/25/23

SUPERCOMPUTERS



Argonne's Aurora Supercomputer, 2022/23

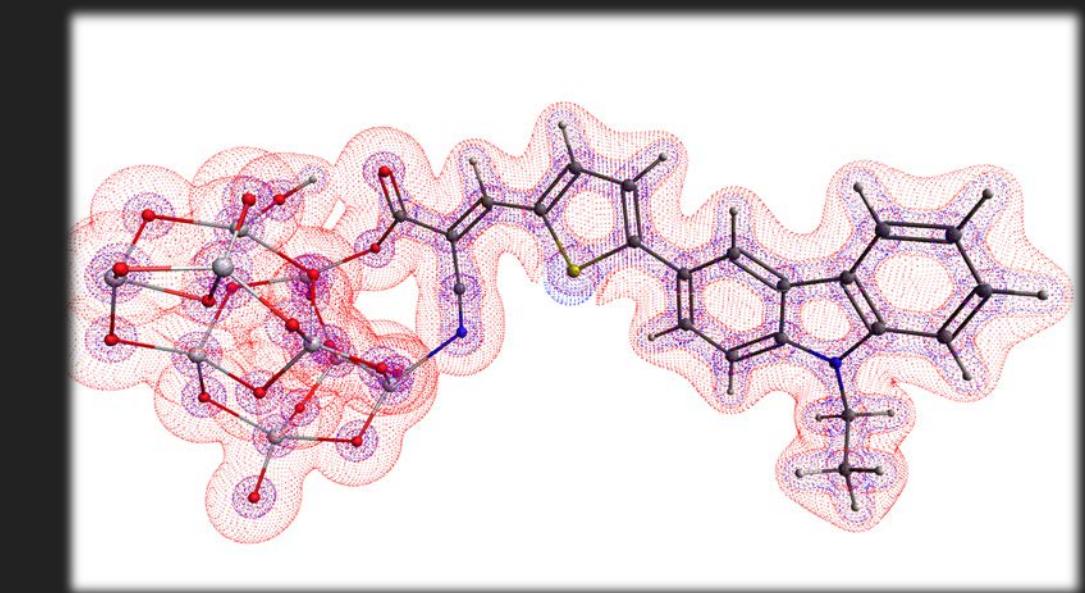
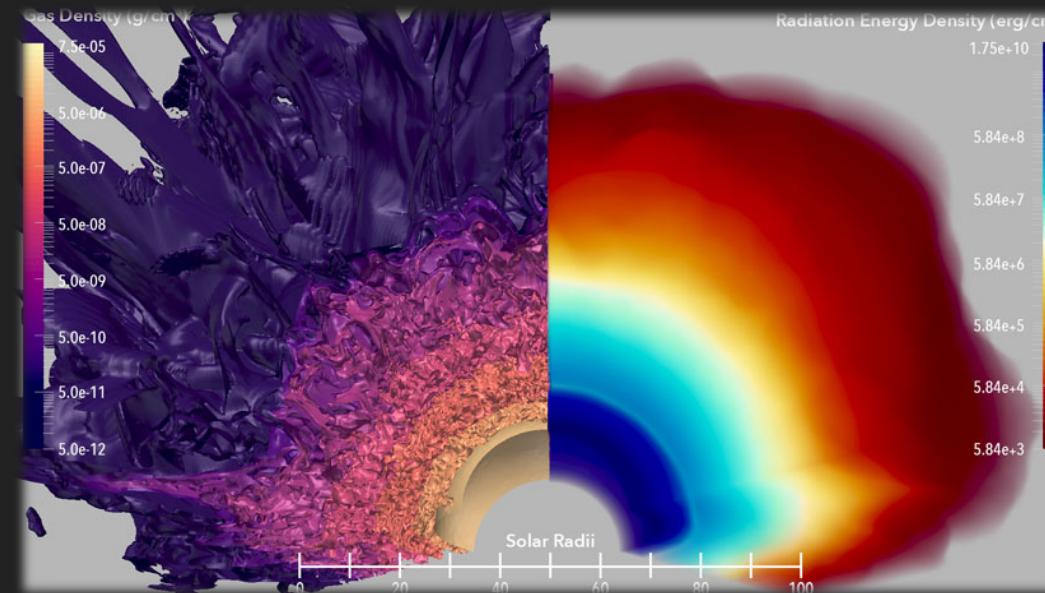
800 megaFLOPS to \sim 2 exaFLOPS

**800,000,000 to
~2,000,000,000,000,000
FLOPS**

2,500,000,000x

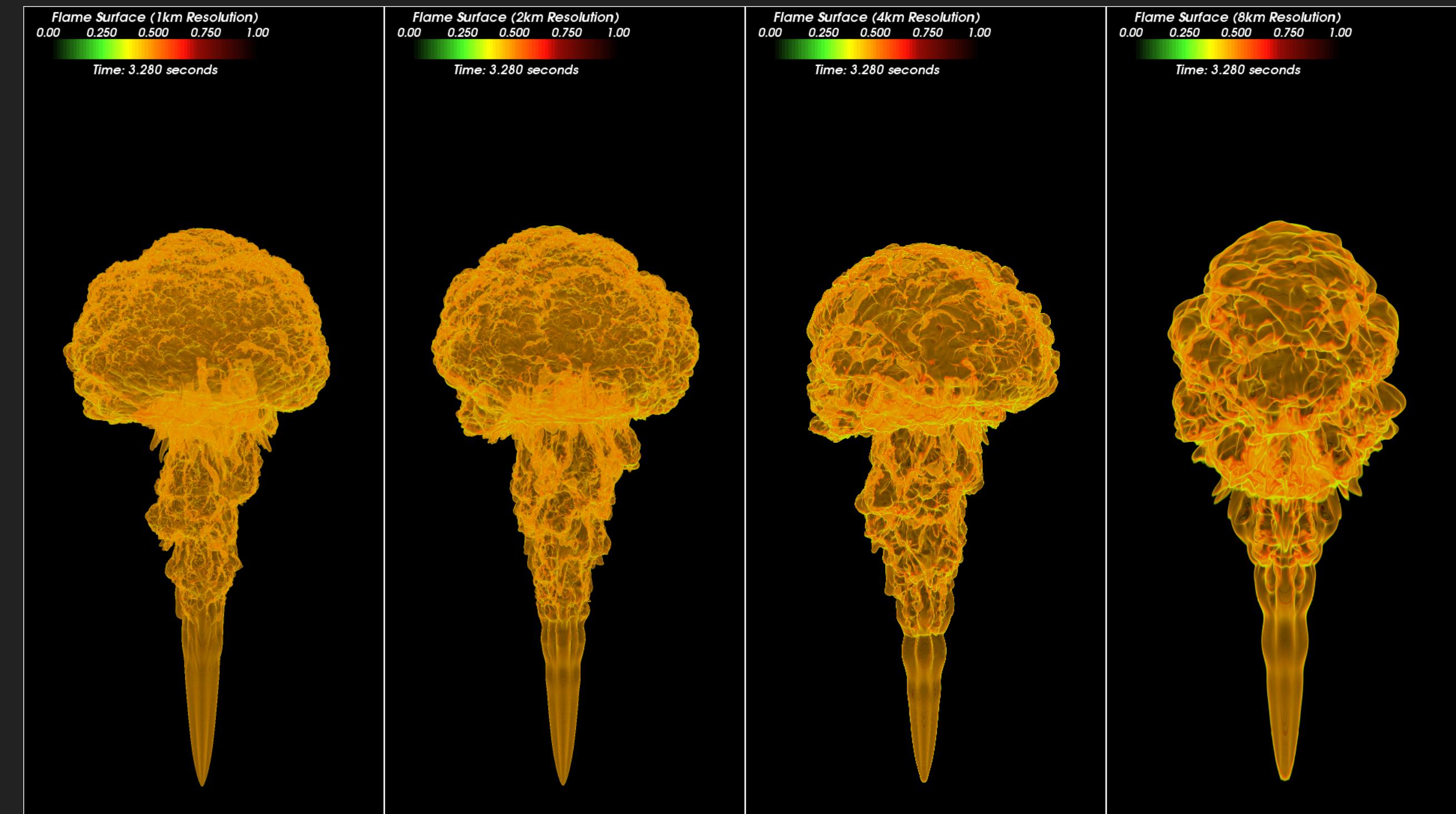
SO WHAT DOES ALL THAT COMPUTE POWER ENABLE?

- ▶ Large-Scale Computing on the Connectomes of the Brain
- ▶ Global Radiation MHD Simulations of Massive Star Envelopes
- ▶ Molecular Design of Dye-Sensitized Solar Cells
- ▶ Real-time Computing in support of DIII-D National Fusion Facility



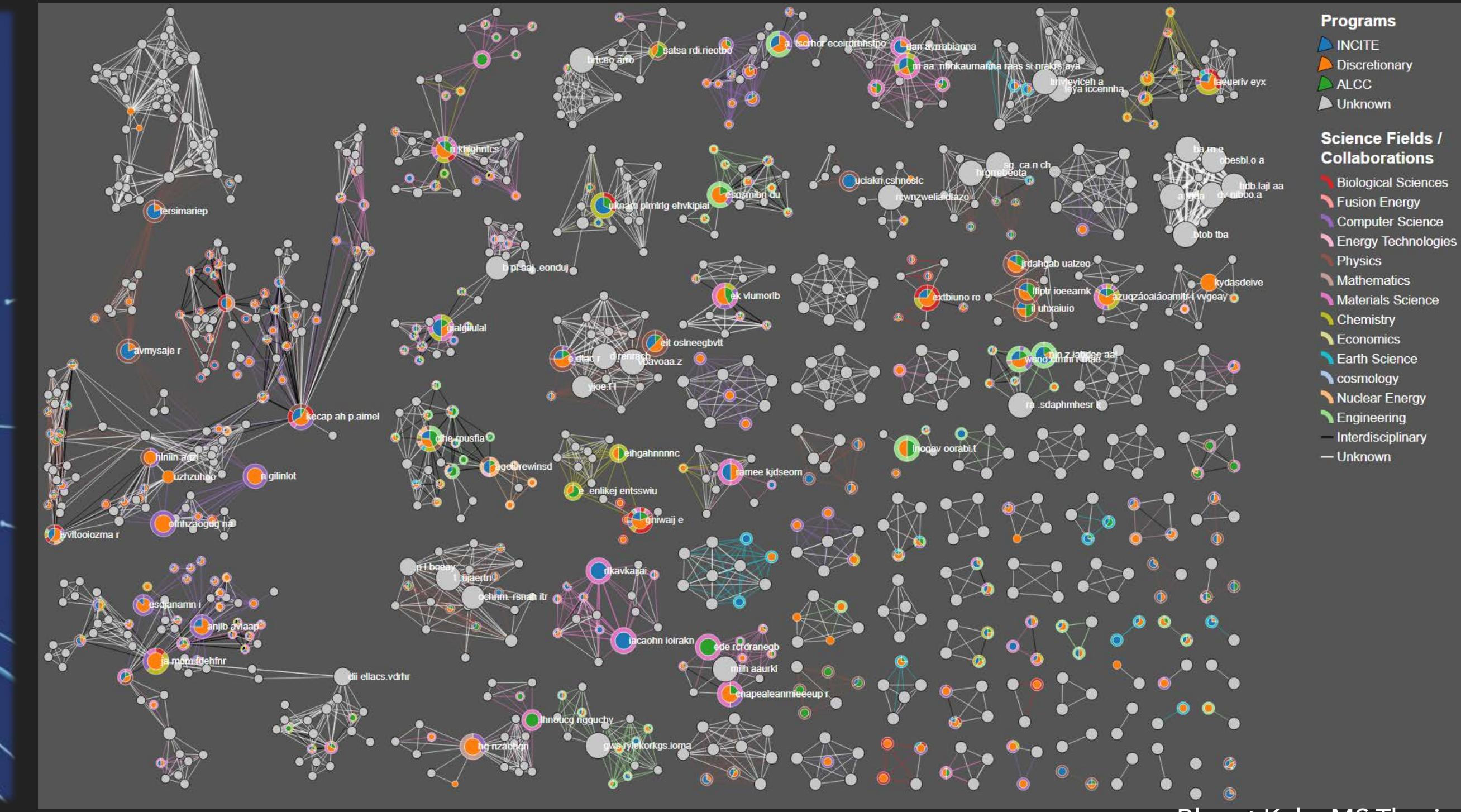
HIGH PERFORMANCE COMPUTING RESEARCH OPPORTUNITIES

- ▶ How do you translate theory into simulation?



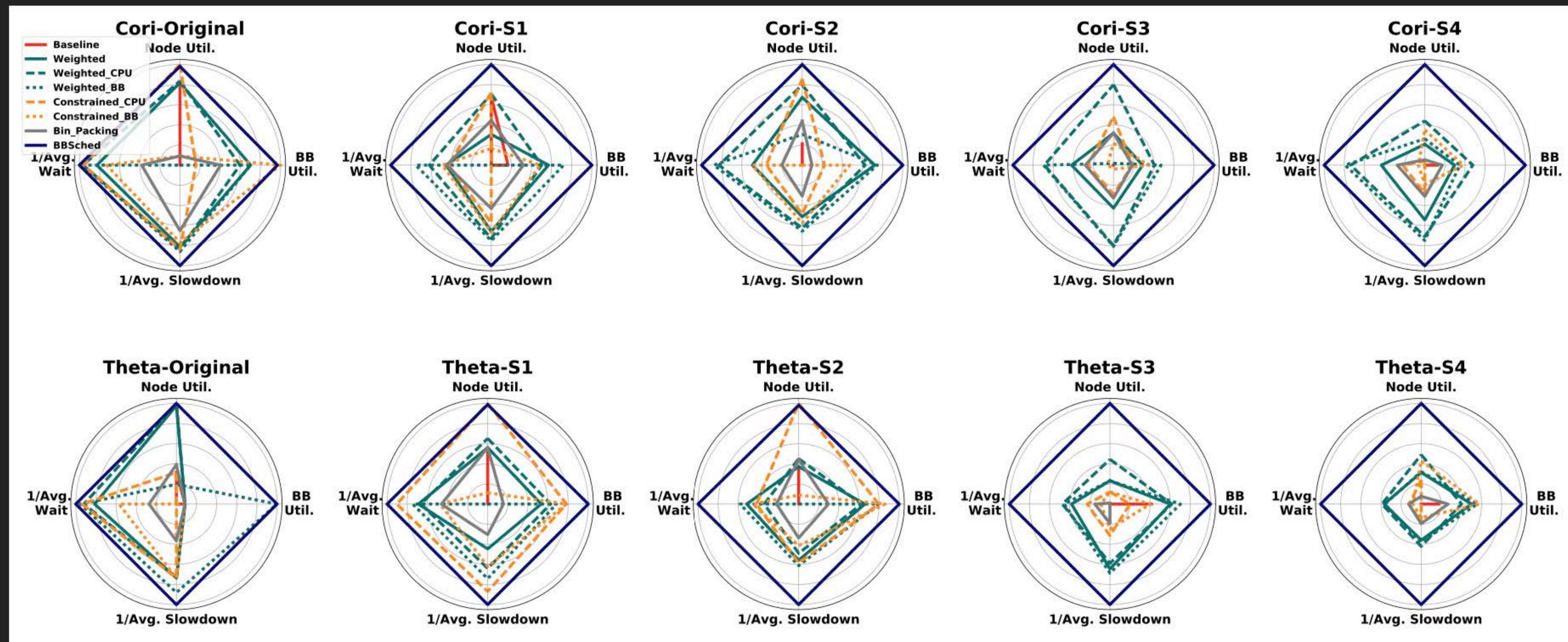
HIGH PERFORMANCE COMPUTING RESEARCH OPPORTUNITIES

- ▶ How do you more efficiently operate a facility?



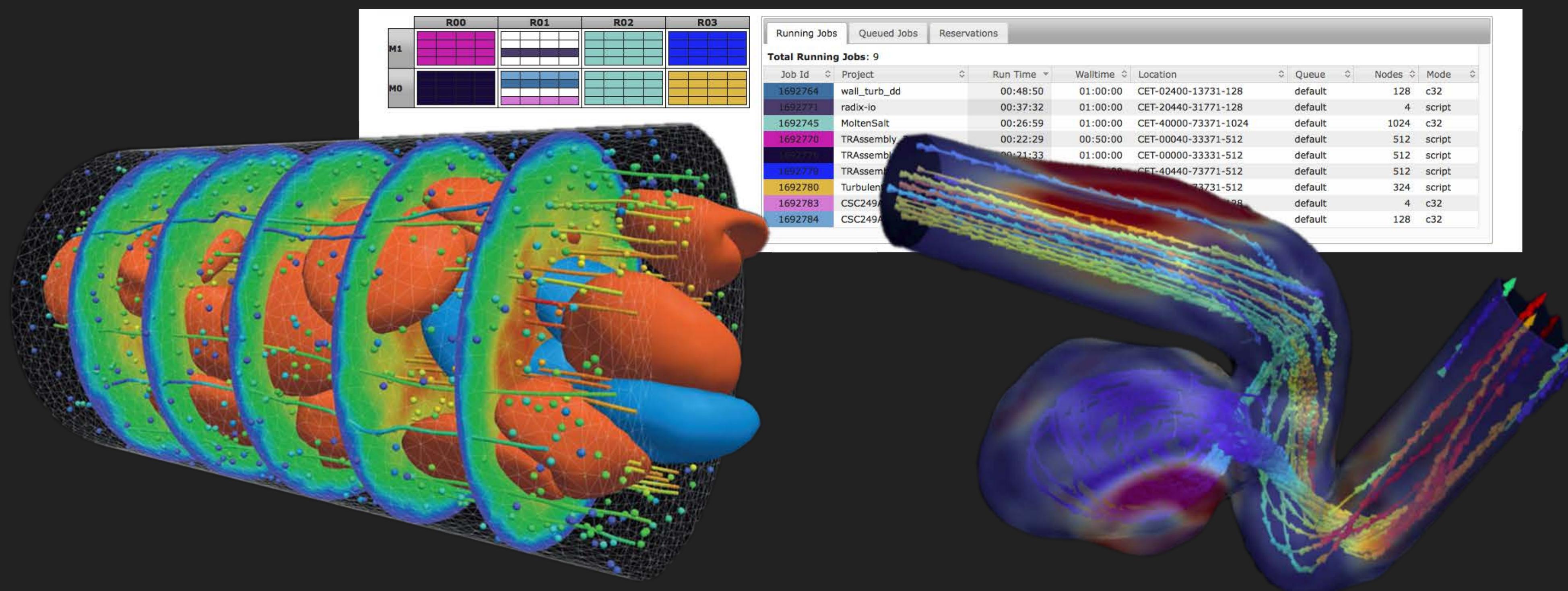
HIGH PERFORMANCE COMPUTING RESEARCH OPPORTUNITIES

- ▶ How do you effectively schedule and operate a resource?



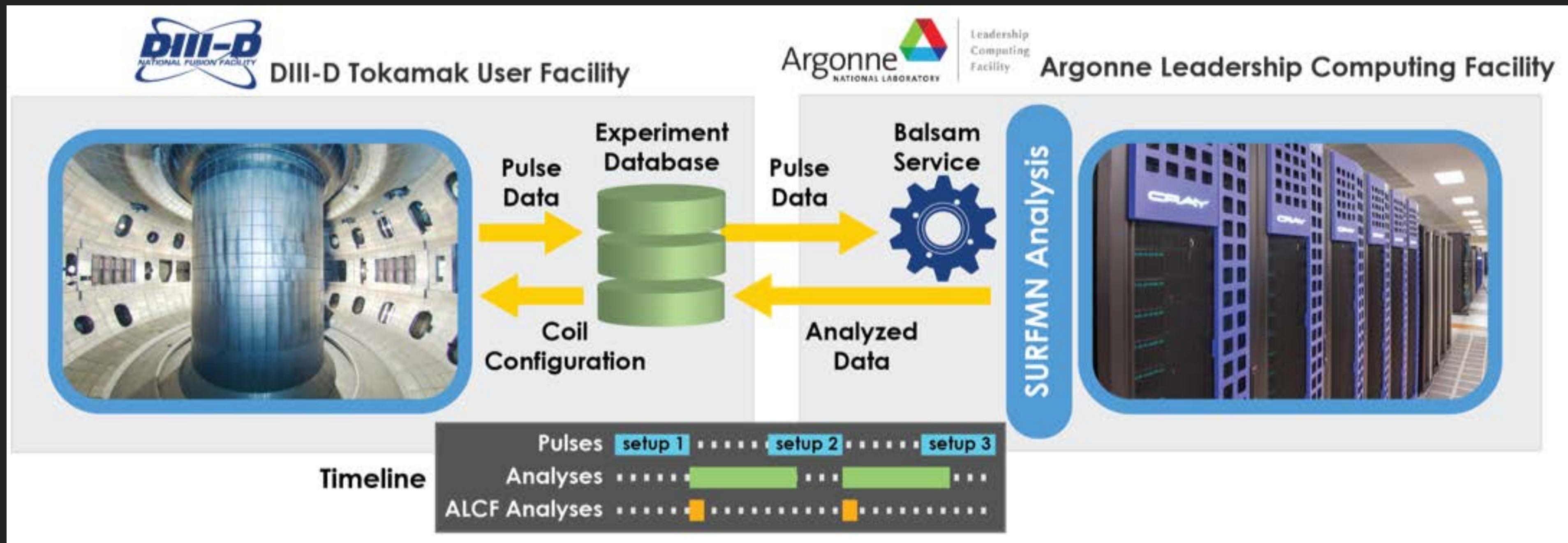
HIGH PERFORMANCE COMPUTING RESEARCH OPPORTUNITIES

- ▶ How do you evolve traditional HPC environment?



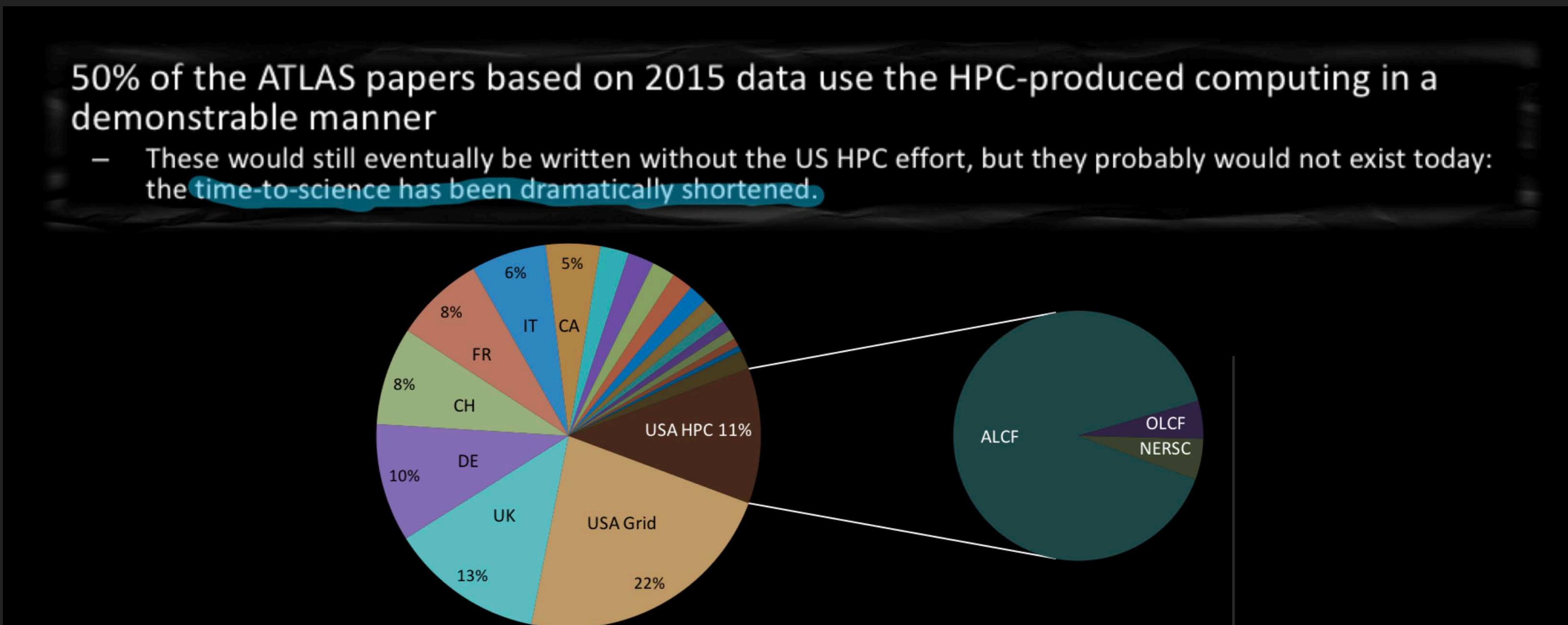
HIGH PERFORMANCE COMPUTING RESEARCH OPPORTUNITIES

- ▶ How do you evolve traditional HPC environment to address real-time needs?



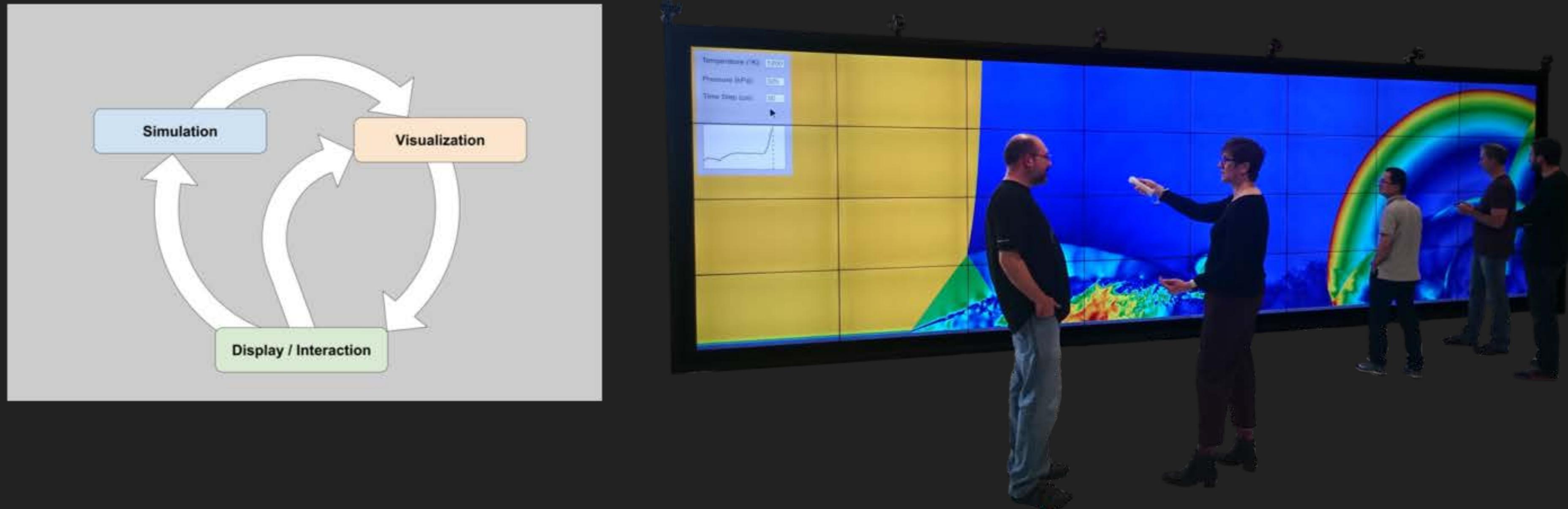
HIGH PERFORMANCE COMPUTING RESEARCH OPPORTUNITIES

► How do you evolve traditional HPC environment handle complex workloads?



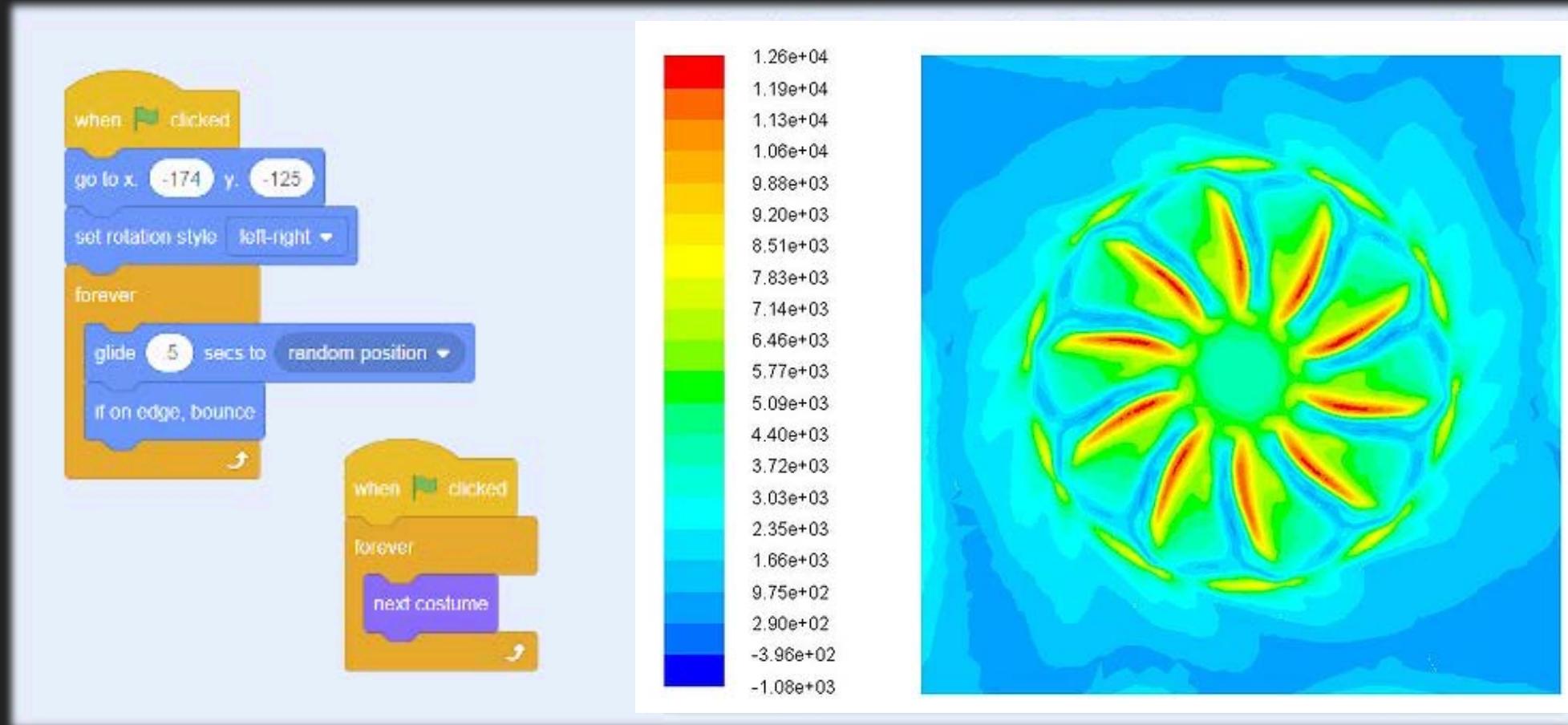
HIGH PERFORMANCE COMPUTING RESEARCH OPPORTUNITIES

- ▶ How do you evolve traditional HPC environment to increase engagement?



HIGH PERFORMANCE COMPUTING RESEARCH OPPORTUNITIES

- ▶ How do we **enable** scientists to be the most **productive** from **start to finish**?
- ▶ How do we improve **usability**?
- ▶ How do we **simplify** supercomputing?

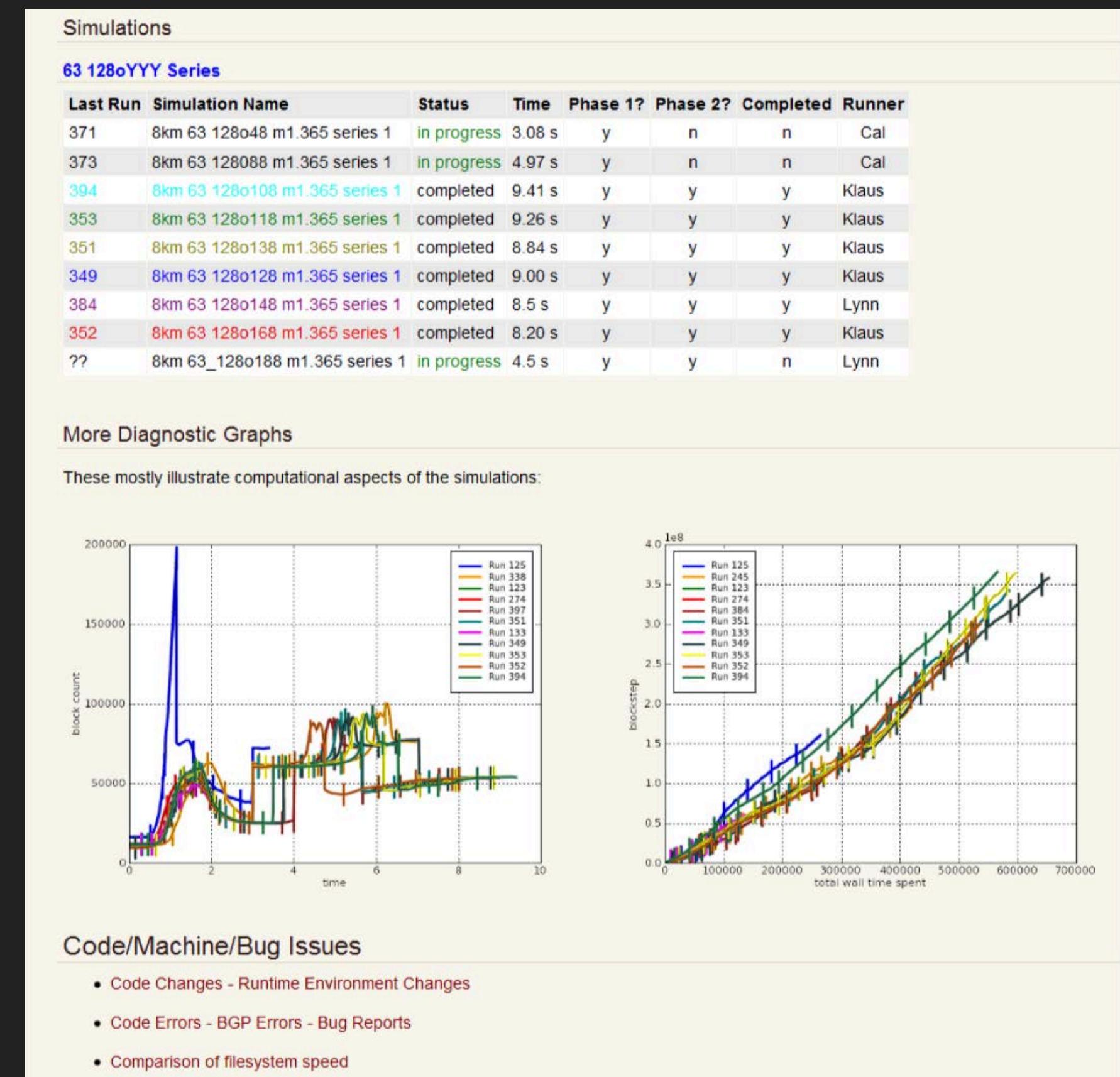


HIGH PERFORMANCE COMPUTING RESEARCH OPPORTUNITIES

- ▶ How do we enable scientists to be the most productive from start to finish?
- ▶ Problems with science management:
 - ▶ Tracking simulations and output: **burdensome**
 - ▶ Finding and reproducing old simulations: **difficult**
 - ▶ Monitoring live simulations: **inconvenient, idiosyncratic**
 - ▶ Post-processing, analysis and archival of results: **haphazard**
 - ▶ Assessing simulation behavior/performance: **challenging**

HIGH PERFORMANCE COMPUTING RESEARCH OPPORTUNITIES

- ▶ How do we enable scientists to be the most productive from start to finish?
- ▶ Simulation management and analysis system for Flash (Smaash)
 - ▶ Tracking and coordination of data (simulation and meta)
 - ▶ Run-time monitoring of simulations and automated analysis of simulation output
 - ▶ Method for managing / executing common workflows



HIGH PERFORMANCE COMPUTING RESEARCH OPPORTUNITIES

- ▶ How do we enable scientists to be the most productive from start to finish?

The figure displays three screenshots of the Smaash/HACC web interface, showing different aspects of the simulation process:

- Model: MiraU / M019 / L2100**: This screen shows a log-log plot of the primordial power spectrum $P(k)$ versus wavenumber k . The y-axis ranges from 10^{-1} to 10^5 , and the x-axis ranges from 10^{-2} to 10^1 . Multiple curves represent different power spectrum components, labeled with their respective k values.
- Run: MiraU / M019 / run001 / L2100**: This screen shows a table of simulation timesteps. The columns include Timestep, Run, Model, Simulation, Date, and Size. The table lists 21 entries, all from run001, dated 1 day, 16 hours ago, with sizes ranging from 1 to 1 MB.
- Run: MiraU / M019 / run000 / L2100**: This screen shows the contents of the file `/homes/turam/dev/smaash/data/589/indat.params`. The file contains cosmological parameters and simulation settings, including `DEUT`, `OMEGA_CDM`, `OMEGA_NU`, `Hubble`, `SS8`, `NS`, `W_DE`, `DEUT`, `OMEGA_CDM`, `DEUT`, `OMEGA_NU`, `Hubble`, `SS8`, `NS`, `W_DE`, `T_CMB`, `N_EFF_MASSLESS`, and `N_EFF_MASSIVE`.

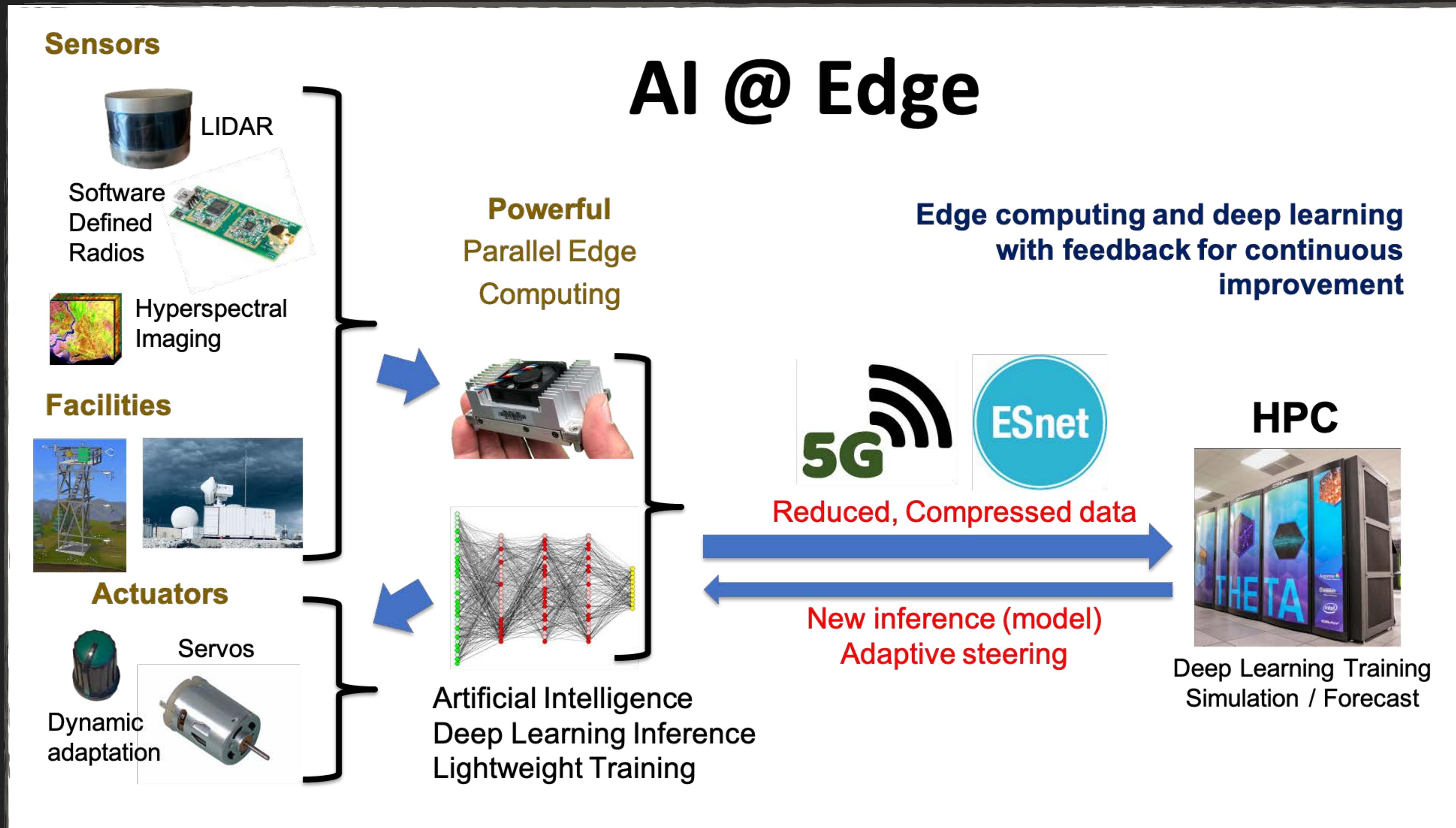
HIGH PERFORMANCE COMPUTING RESEARCH OPPORTUNITIES

- ▶ How do we enable scientists to be the most productive from start to finish?

The collage consists of four panels:

- Left Panel:** A dashboard showing four visualization options: "Basic Overview", "Feature-Based", "Fly-Through", and "Time-Varying Data". Each option includes a small preview image and a brief description.
- Middle Left Panel:** A grid of job cards for "APS Basic Job" and "HA_tube5_test2 Basic Job", showing their status as "In Progress" or "Complete".
- Middle Right Panel:** A grid of "Images" showing a series of 2D plots or snapshots of data over time.
- Right Panel:** A detailed view of a specific job card for "HA_tube5_test2 Basic Job" with job details like ID, type, creator, and timestamps, along with a "Comments" section and download links.

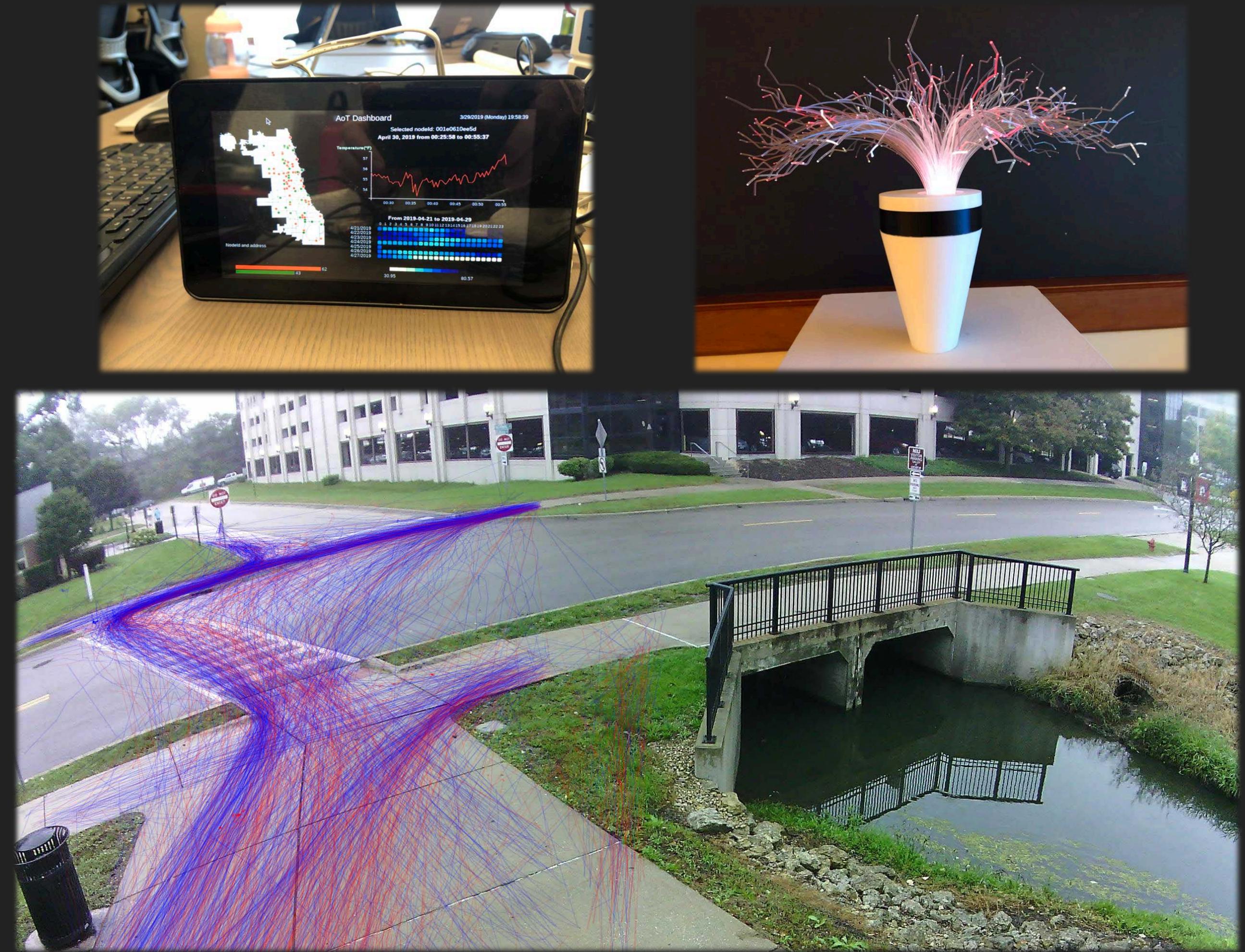
INTERNET OF THINGS (COMPUTING CONTINUUM) [EDGE COMPUTING]



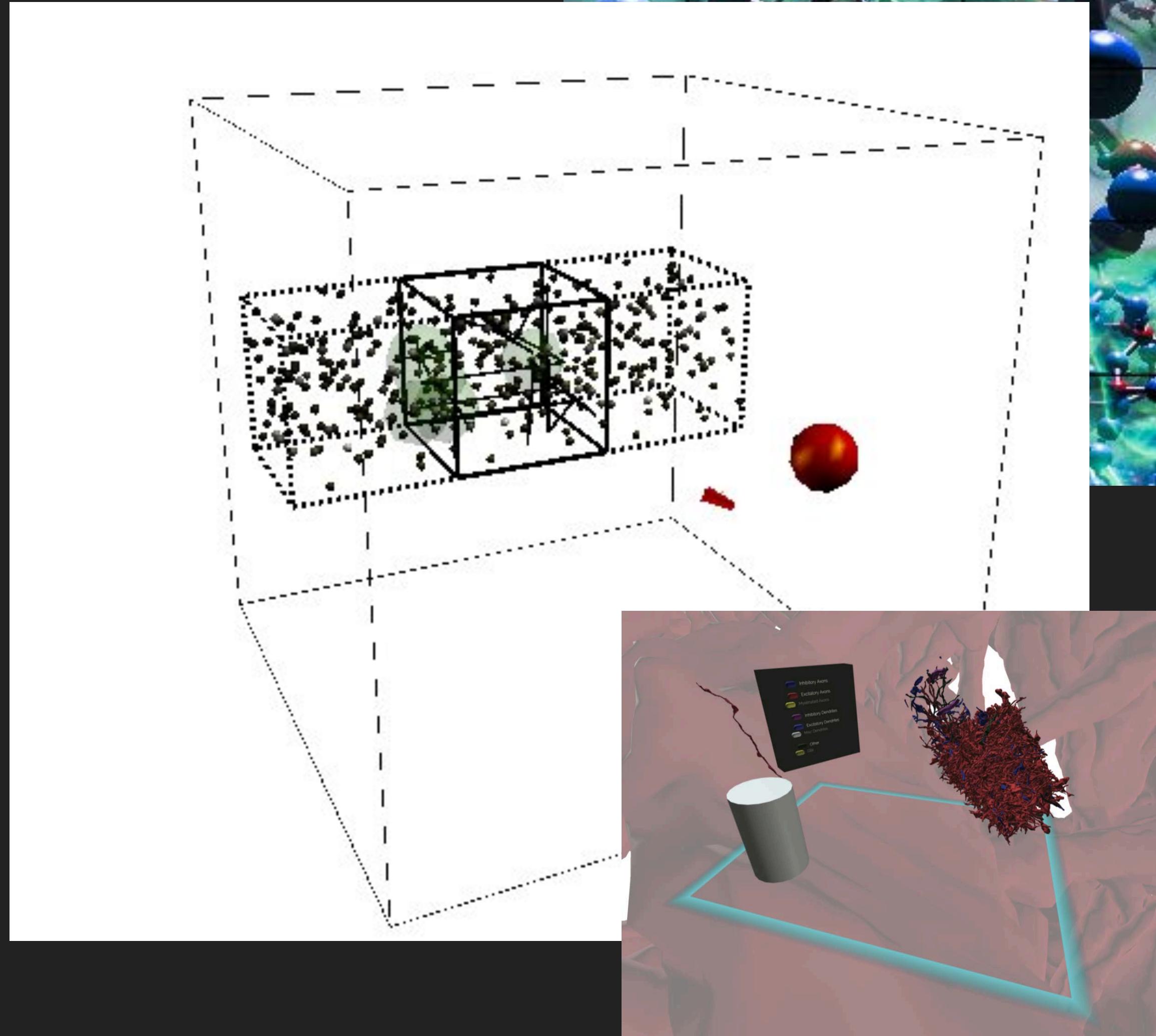
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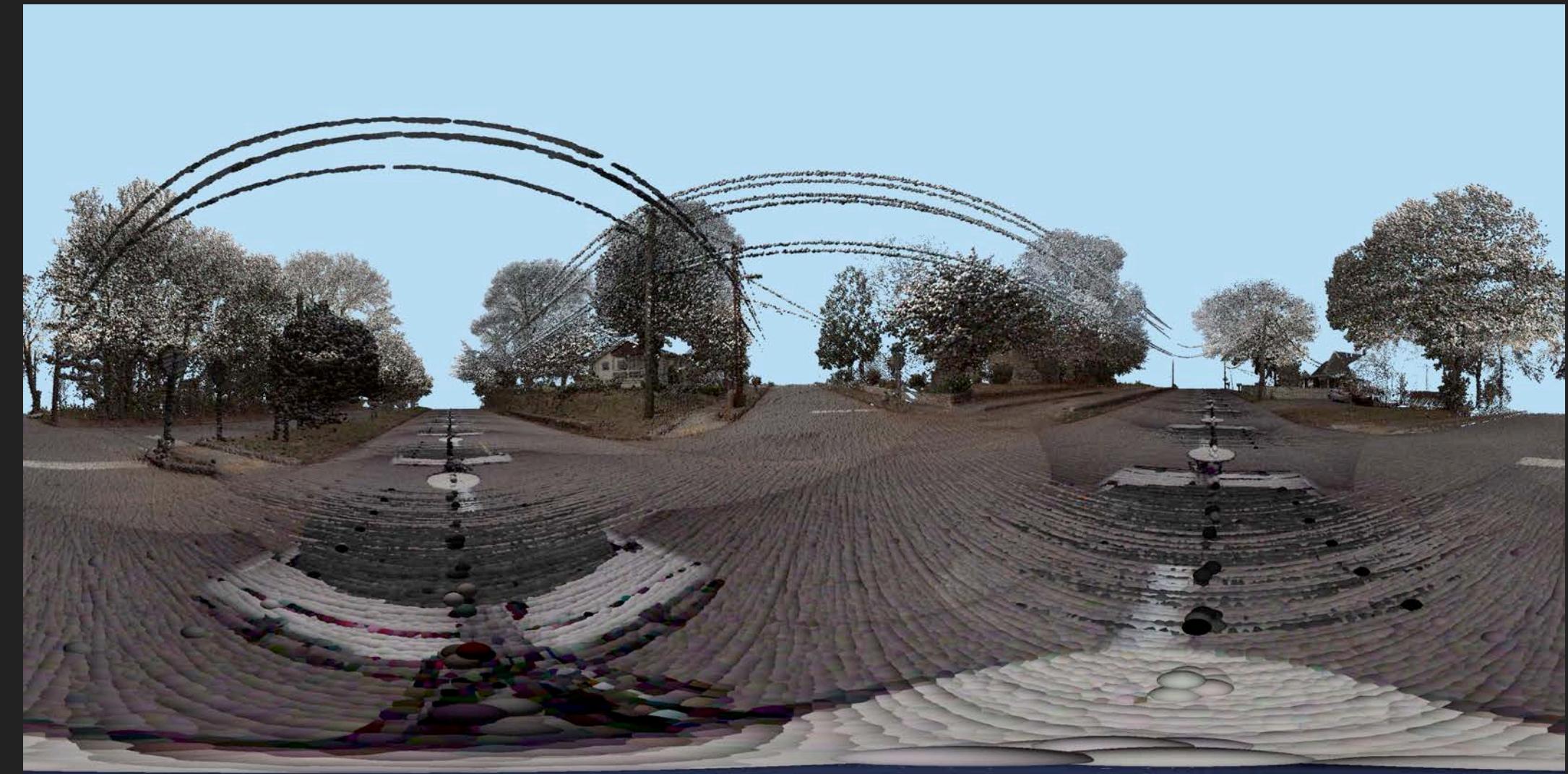
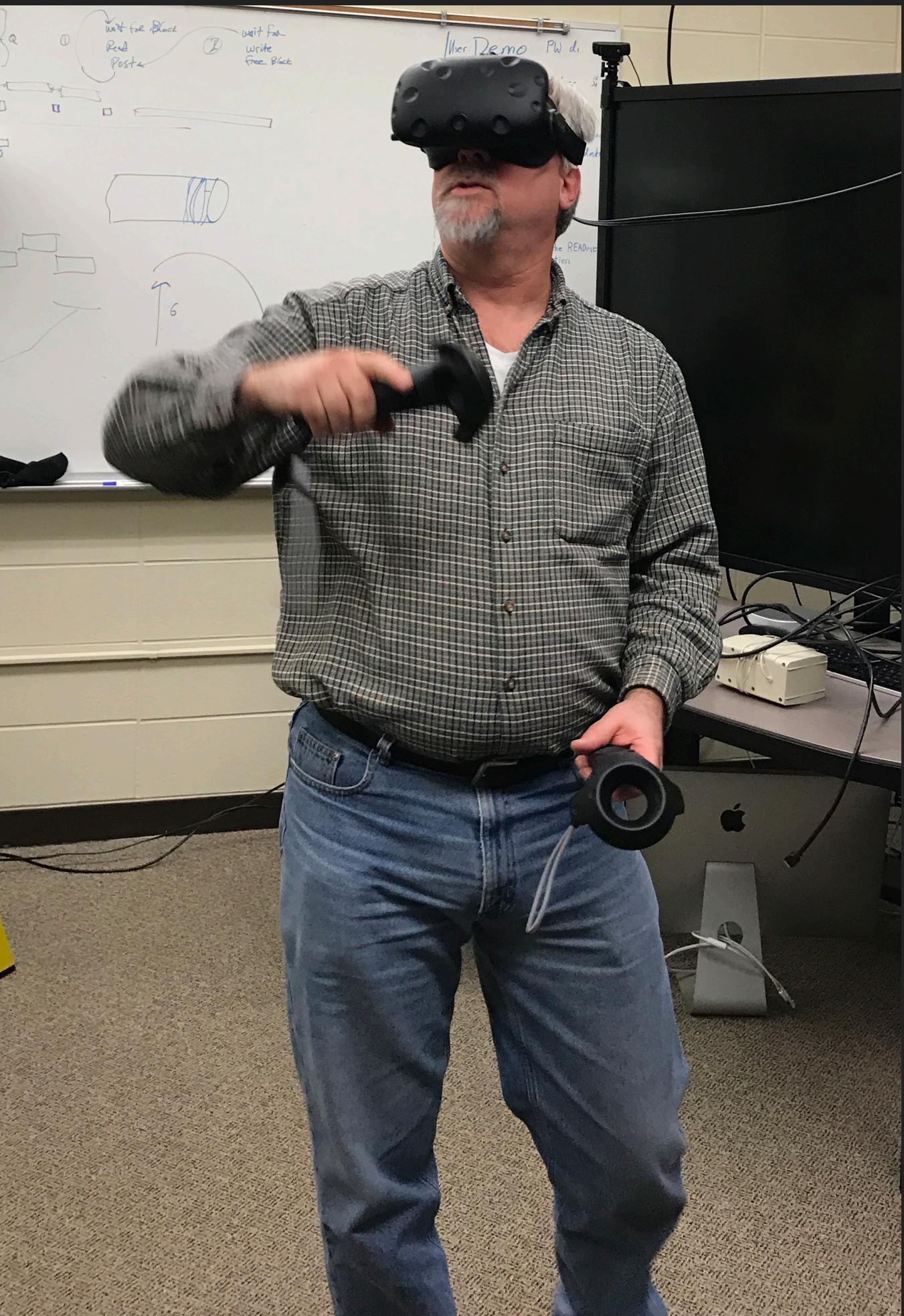
VIRTUAL REALITY



Use of **Virtual Reality** in Science

- ▶ Usability, virtual interactions
- ▶ Rendering, realistic data in VR time

VIRTUAL REALITY



SUMMER RESEARCH OPPORTUNITIES (IN PERSON NORMALLY, CURRENTLY VIRTUAL)



ACKNOWLEDGMENTS

- ▶ Current funding is provided by the *Argonne Leadership Computing Facility* a DOE Office of Science User Facility supported under contract DE-AC02-06CH11357 with additional support from the National Science Foundation grant OAC-1935984 and CCF-2119056.
- ▶ Thanks to all the students of the ddiLab and my colleagues at NIU and ANL.



Spring 2019 ddiLab

If I have seen further it is by standing on the shoulders of giants.

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Sir Isaac Newton

