Neuromorphic Computing

-Beyond CMOS Emerging Computing Architectures-

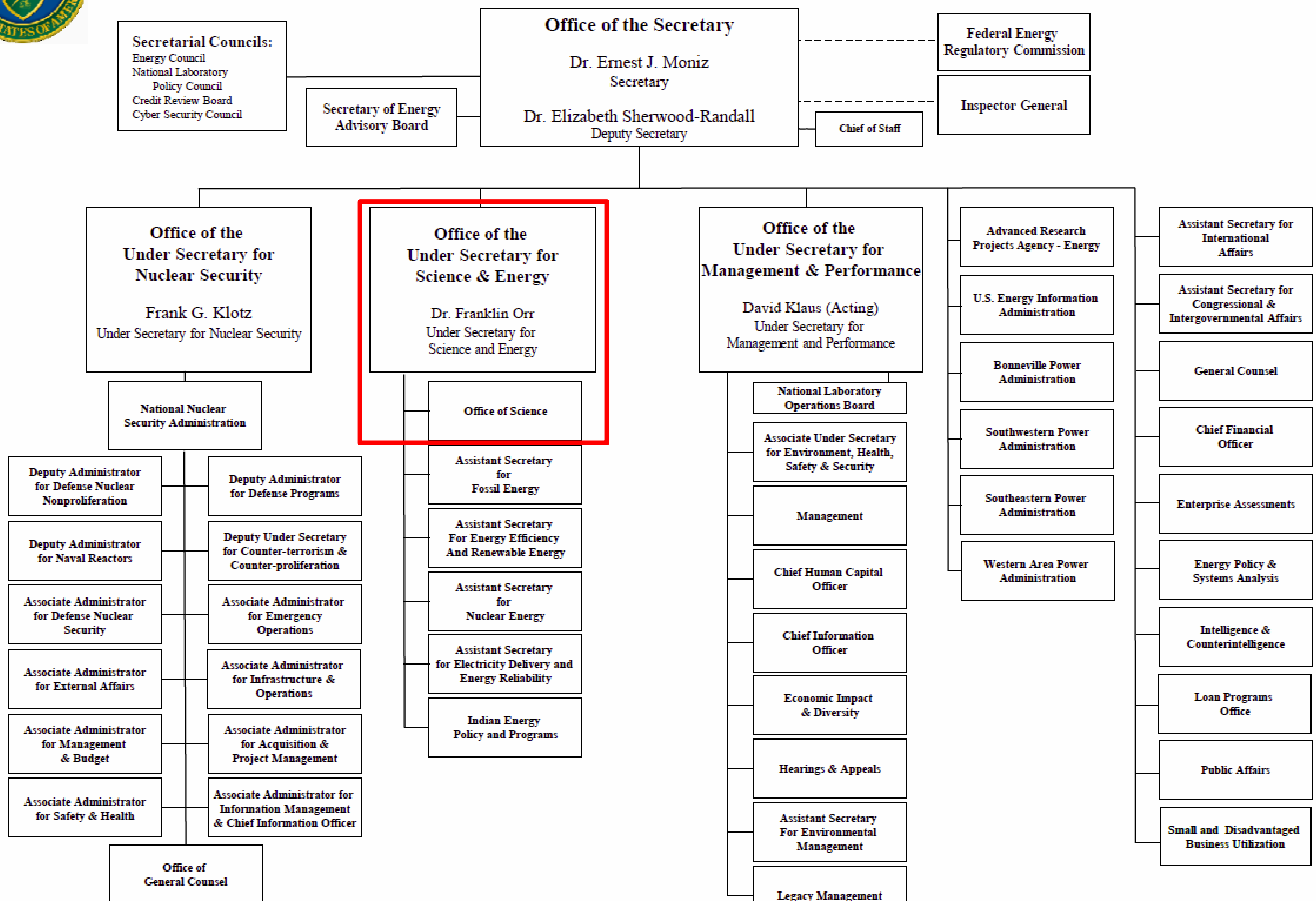
-Future Computing-

Advanced Scientific Computing Research (ASCR)

Dr. Robinson Pino
Program Manager
Robinson.Pino@science.doe.gov

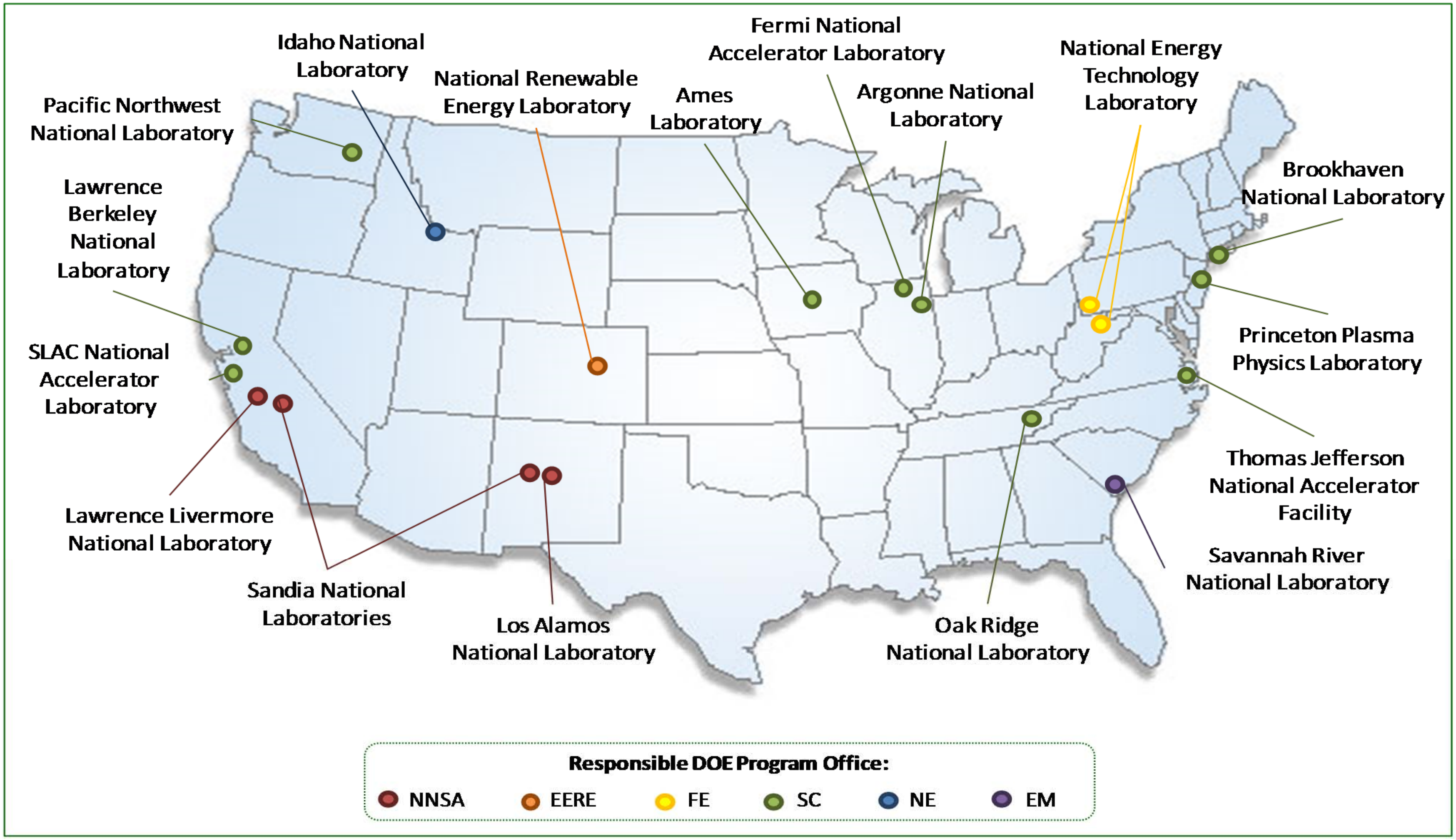
June 29, 2016

DEPARTMENT OF ENERGY



17 Dec 2014

DOE's 17 National Laboratories



Quick-Facts about the DOE Office of Science

Advanced Scientific Computing Research (ASCR)

Basic Energy Sciences (BES)

Biological and Environmental Research (BER)

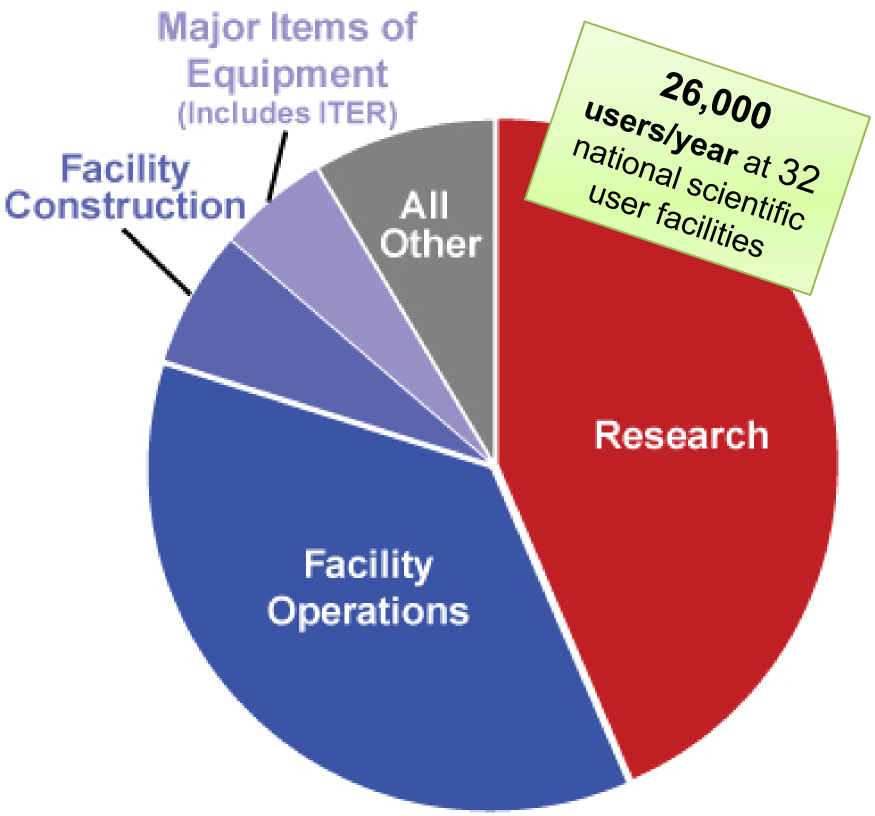
Fusion Energy Sciences (FES)

High Energy Physics (HEP)

Nuclear Physics (NP)

DOE Office of Science – At a Glance

FY 2015 Funding
Total = $5.140 billion

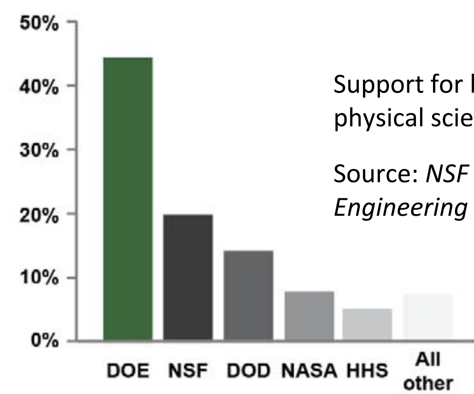


Source: http://science.energy.gov/about/

<u>Mission</u>: SC delivers scientific discoveries and tools to transform our understanding of nature and advance the energy, economic, and national security of the U.S.

<u>Research</u>

- Support for 47% of the U.S. Federal support of basic research in the physical sciences;
- ~22,000 Ph.D. scientists, grad students, engineers, and support staff at >300 institutions, including all 17 DOE labs;
- U.S. and world leadership in high-performance computing and computational sciences;
- Major U.S. supporter of physics, chemistry, materials sciences, and biology for discovery and for energy sciences.



Support for basic research in the physical sciences by agency.

Source: *NSF Science and Engineering Indicators 2012*

<u>Scientific User Facilities</u>

- The world's largest collection of scientific user facilities (aka research infrastructure) operated by a single organization in the world, used by 31,000 researchers each year.

U.S. DEPARTMENT OF ENERGY | Office of Science

Advanced Scientific Computing Research

Computational and networking capabilities to extend the frontiers of science and technology

- **Mathematics research** to address challenges of increasing complexity within DOE's mission areas from a mathematical perspective. This requires integrated, iterative processes across multiple mathematical disciplines.
- **Computer science research** to increase the productivity and integrity of HPC systems and simulations, and support data management, analysis, and visualization techniques.
- **SciDAC partnerships** to dramatically accelerate progress in scientific computing that delivers breakthrough scientific results.
- **Exascale computing** research and development of capable exascale hardware architectures and system software, including the deployment of programming environments for energy-efficient, data-intensive applications, and engagement with HPC vendors to deliver systems that address the exascale challenges.
- **Facilities** operate with at least 90% availability while continuing planned upgrades – begin deployment of 10-40 petaflop upgrade at NERSC and continue preparations for 75-200 petaflop upgrades at each LCF.
- **CSGF** - Continue a postdoctoral program at the ASCR facilities and provide funding for the Computational Science Graduate Fellowship to address DOE workforce needs.

Leadership Computing for Scientific Discovery

#1

OLCF Titan System Specifications:

- Peak performance of 27.1 Petaflops
  - 24.5 GPU + 2.6 CPU
- 18,688 Hybrid Compute Nodes with:
  - 16-Core AMD Opteron CPU
  - NVIDIA Tesla “K20x” GPU
  - 32 + 6 GB memory
- 200 Cabinets; 710 TB total system memory; 8.9 MW peak power

- Peer reviewed projects are chosen to advance science, promote innovation, and strengthen industrial competitiveness.
- Demand for these machines has grown each year, requiring recent upgrades of both.

ALCF Mira System Specifications:

- Peak performance of 10 Petaflops
- 49,152 Compute Nodes each with:
  - 16-Core Power PC A2 CPU with 64 Hardware Threads and 16 Quad FPUs
  - 16 GB memory
- 56 Cabinets; 786 TB total system memory; 4.8 MW peak power

FY 2013 research projects include; advancing materials for lithium air batteries, solar cells, and superconductors ; improving combustion in fuel-efficient, near-zero-emissions systems; understanding how turbulence affects the efficiency of aircraft and other transportation systems; designing next-generation nuclear reactors and fuels ; developing fusion energy systems

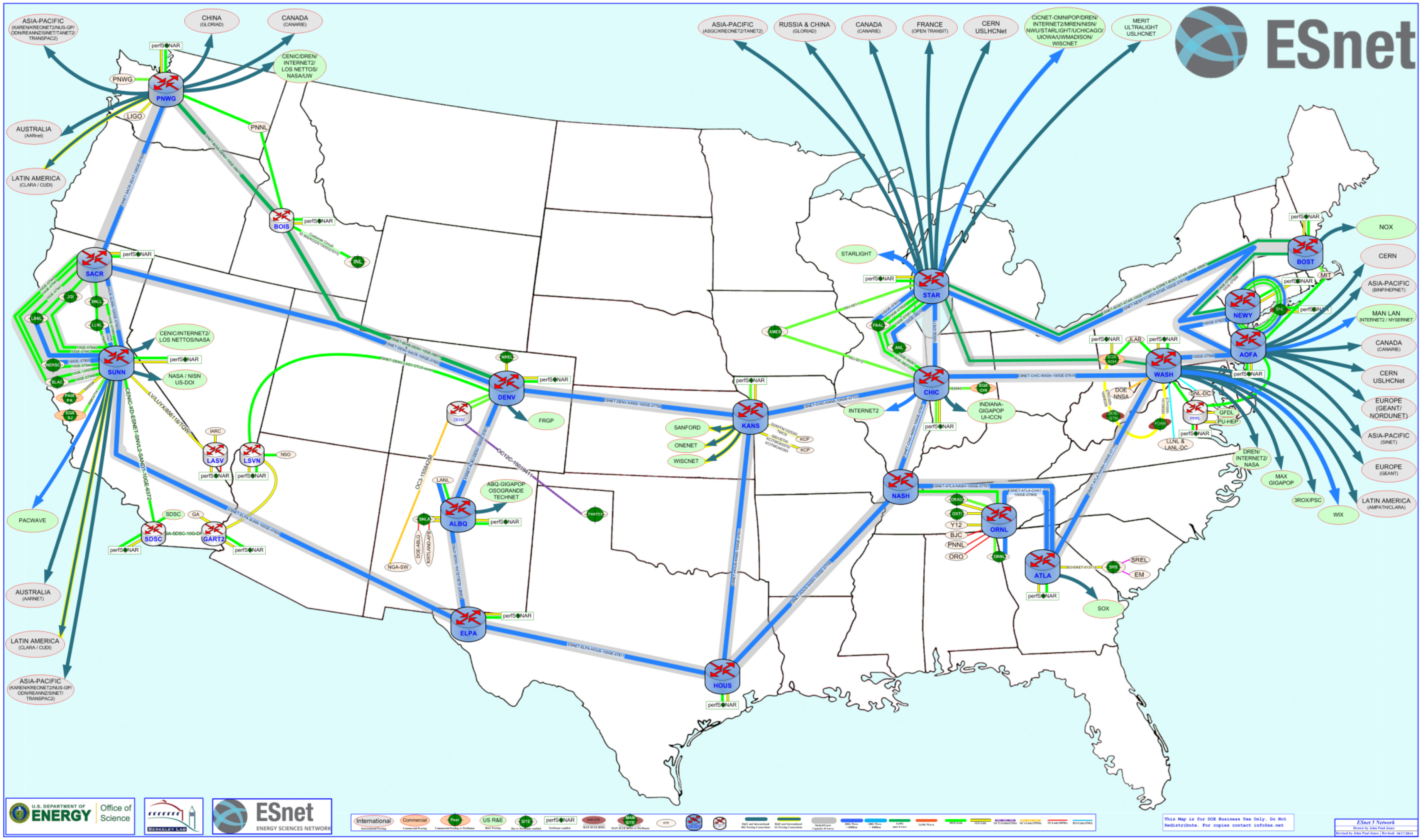
NERSC: 40 years of High Performance Computing for DOE

System Specifications:

- *Hopper XT5 (2010)*
  - 1.3PF, 212TB, 2.9 MW peak power
- *Edison XC30 (in acc*
  - Based on DARPA/DOE HPCS system
  - 2.4PF, 333TB, 2.1 MW peak power
- *400TF mixed use clusters*
  - NERSC, JGI, HEP/NP, Materials, Kbase

Computational Research and Theory Building will provide 12 MW power and cooling for future NERSC computing resources

Energy Sciences Network (Esnet)



/www.whitehouse.gov/blog/2015/10/15/nanotechnology-inspired-grand-challenge-future-computing

the WHITE HOUSE PRESIDENT BARACK OBAMA — Contact Us ▸ Get Email Updates ▸

BRIEFING ROOM | ISSUES | THE ADMINISTRATION | PARTICIPATE | 1600 PENN

HOME · BLOG

A Nanotechnology-Inspired Grand Challenge for Future Computing

OCTOBER 20, 2015 AT 6:00 AM ET BY LLOYD WHITMAN, RANDY BRYANT, AND TOM KALIL

Summary: Today, the White House is announcing a grand challenge to develop transformational computing capabilities by combining innovations in multiple scientific disciplines.

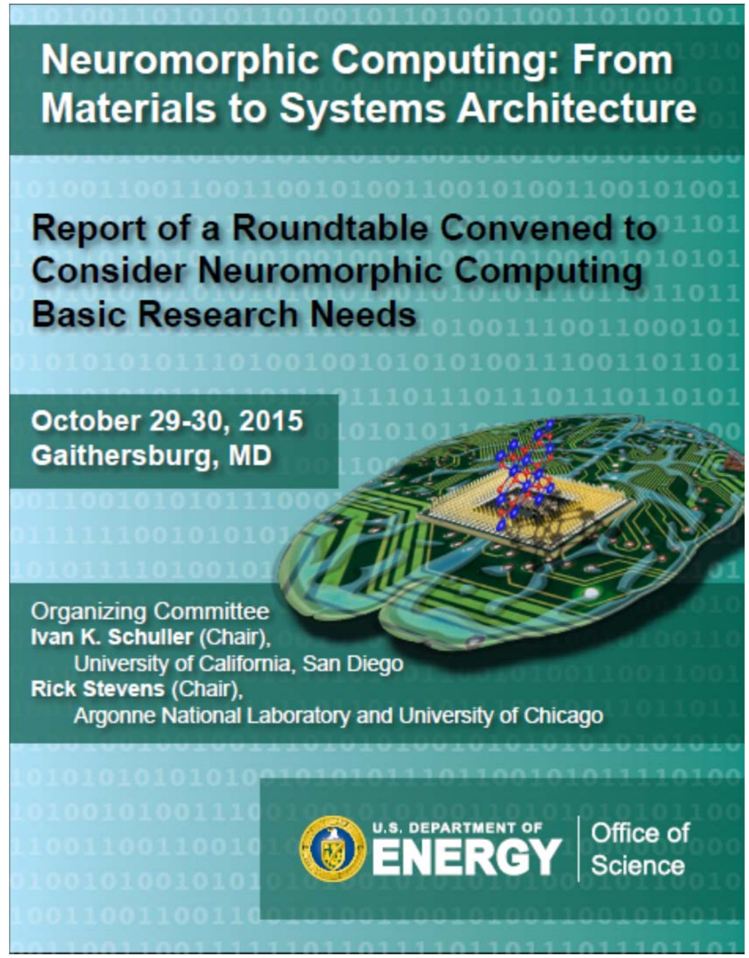
In June, the Office of Science and Technology Policy issued a Request for Information seeking suggestions for *Nanotechnology-Inspired Grand Challenges for the Next Decade.* After considering over 100 responses, OSTP is excited to announce the following grand challenge that addresses three Administration priorities—the National Nanotechnology Initiative, the National Strategic Computing Initiative (NSCI), and the BRAIN initiative:

Create a new type of computer that can proactively interpret and learn from data, solve unfamiliar problems using what it has learned, and operate with the energy efficiency of the human brain.

https://www.whitehouse.gov/blog/2015/10/15/nanotechnology-inspired-grand-challenge-future-computing

Organizing Committee

- **Chairs**
  - Rick Stevens
    - Argonne National Lab and University of Chicago
  - Ivan K. Schuller
    - University of California, San Diego
- **DOE Contacts**
  - Robinson Pino
    - Advanced Scientific Computing Research (ASCR)
  - Michael Pechan
    - Basic Energy Sciences (BES)
- **Sponsored by ASCR and BES**
  - Evaluate both advanced materials and scientific computing research opportunities to support development of a new paradigm for extreme and self-reconfigurable computing architectures that go beyond Moore's Law and mimic neuro-biological computing architectures
    - Approximately 20 experts in emerging computer architectures and related materials science research topics were be invited



http://science.energy.gov/~/media/ascr/pdf/programdocuments/docs/Neuromorphic-Computing-Report_FNLBLP.pdf

Summary

- **High pay-off research and development**
- **Foundational technology for:**
  - ✓ **Systems able to perform autonomous operations**
  - ✓ **Sense-making for scientific discovery**
  - ✓ **Accelerated and reconfigurable in situ analysis**
- **Plenty of opportunity to make substantial contribution in the area of information processing and *understanding***
- **Brain-inspired architectures in software or hardware offer a path for much needed technological evolution**
- **It is truly a multi- and cross-disciplinary effort in materials, physics, chemistry, biology, mathematics, engineering, computer science, neuroscience, etc., to ensure success in this field**

Thank you!

Dr. Robinson Pino
Robinson.Pino@science.doe.gov

http://science.energy.gov/ascr/

"If we are to achieve results never before accomplished, we must expect to employ methods never before attempted."

Sir Francis Bacon