U.S. DEPARTMENT OF ENERGY | Office of Science

Comments from the Office of Science

Briefing for HEPAP

06 December 2013

Patricia M. Dehmer
Acting Director, Office of Science
U.S. Department of Energy

Professor Lynn Orr – Nominee for S-4

Professor Franklin "Lynn" Orr has served as director of the Precourt Institute for Energy at Stanford University since 2009. The $100 million Precourt Institute, founded by primary donors Jay Precourt and the husband-and-wife team of Thomas Steyer and Kat Taylor, draws talent from across the campus and around the world to develop sustainable energy solutions and search for ways to reduce atmospheric levels of carbon. The Precourt Institute and the TomKat Center for Sustainable Energy foster Stanford-wide, interdisciplinary research combining science and technology research with research on energy economics, policy, finance and the behavior of energy consumers. Prior to leading the Precourt Institute, Orr served as the founding director of the Global Climate and Energy Project at Stanford from 2002 to 2008.

Since 1985, Orr has been an associate professor and professor in Stanford's Department of Energy Resources Engineering (formerly the Department of Petroleum Engineering). He was dean of the School of Earth Sciences at Stanford from 1994 to 2002 and chairman of the Department of Petroleum Engineering from 1991 to 1994. Orr held several other research positions from 1970 to 1985 in New Mexico, Texas and Washington, D.C. He received his BS degree from Stanford University and PhD from the University of Minnesota.

Professor Lynn Orr

Professor Marc Kastner – Nominee for SC-1

Professor Marc Kastner is the dean of MIT's School of Science and the Donner Professor of Physics. He has been on the MIT faculty since 1973 and has led MIT's Department of Physics and its Center for Materials Science and Engineering.

MIT's School of Science, which Kastner has led since 2007, includes the departments of Biology; Brain and Cognitive Sciences; Chemistry; Earth, Atmospheric and Planetary Sciences; Mathematics; and Physics. The school is home to approximately 300 faculty, 1,200 graduate students, and 1,000 undergraduate majors.

Kastner's early research focused on the electronic and optical properties of amorphous semiconductors. In 1990, his research group fabricated the first semiconductor single-electron transistor; his group continues to use these devices as tools to study the quantum mechanical behavior of electrons confined to nanometer dimensions.

Kastner is a member of the NAS and American Academy of Arts and Sciences, and a fellow of the AAAS and the APS. He received a B.S. in chemistry, an M.S. in physics, and a Ph.D. in physics from the University of Chicago.

Professor Marc Kastner

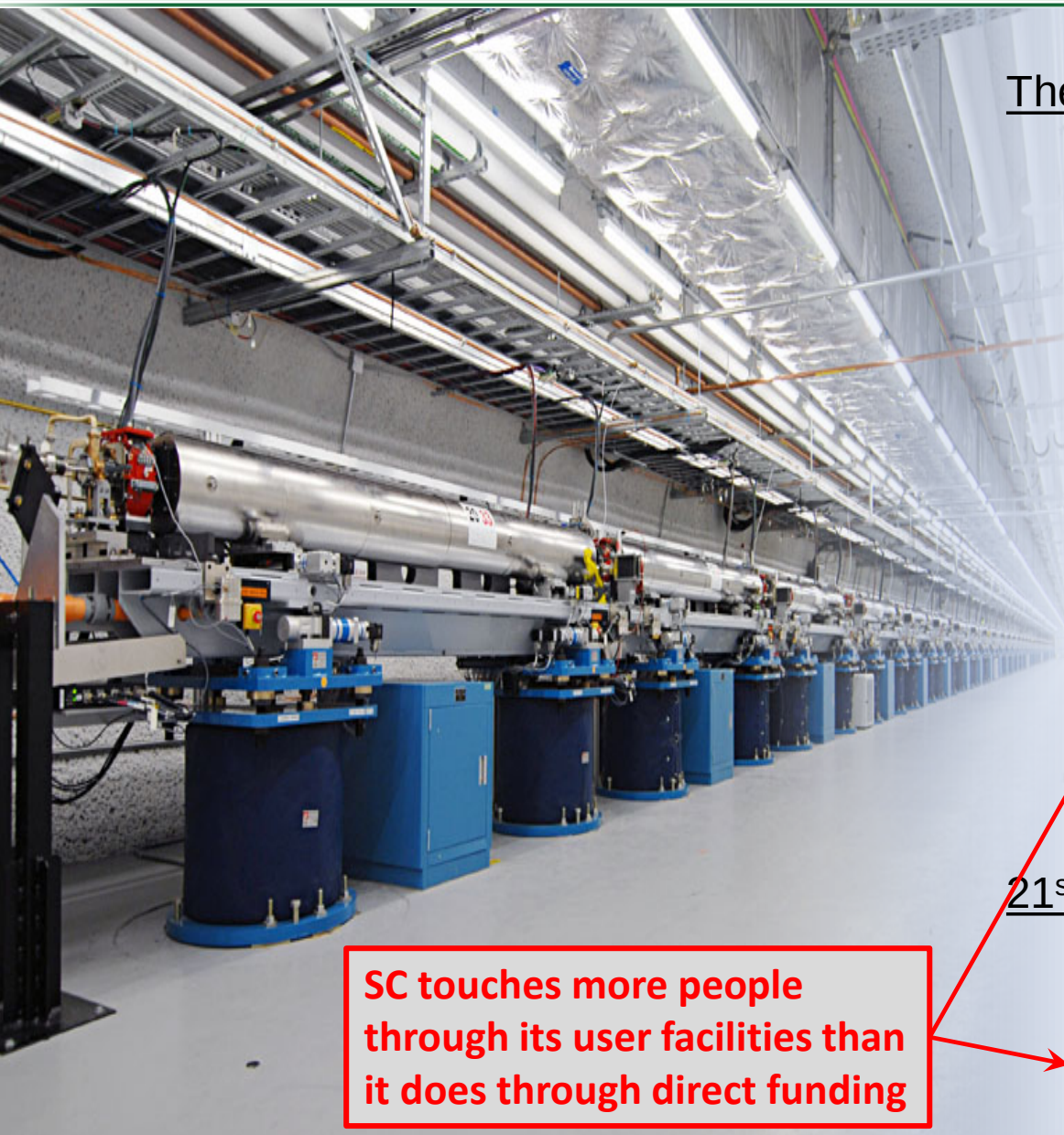
Outline

- Some reflections on prioritization of science and scientific facilities, esp. as they relate to HEP

- An example of an SC/BES FACA study that led to immediate impacts for the field and its facilities

SC's Scientific User Facilities

Office of Science



The Frontiers of Science

- Supporting research that led to over 100 Nobel Prizes during the past 6 decades—more than 20 in the past 10 years
- Supporting 25,000 Ph.D. scientists, graduate students, undergraduates, engineers, and support staff at more than 300 institutions
- Providing 45% of Federal support of basic research in the physical and energy related sciences and key components of the Nation's basic research in biology and computing

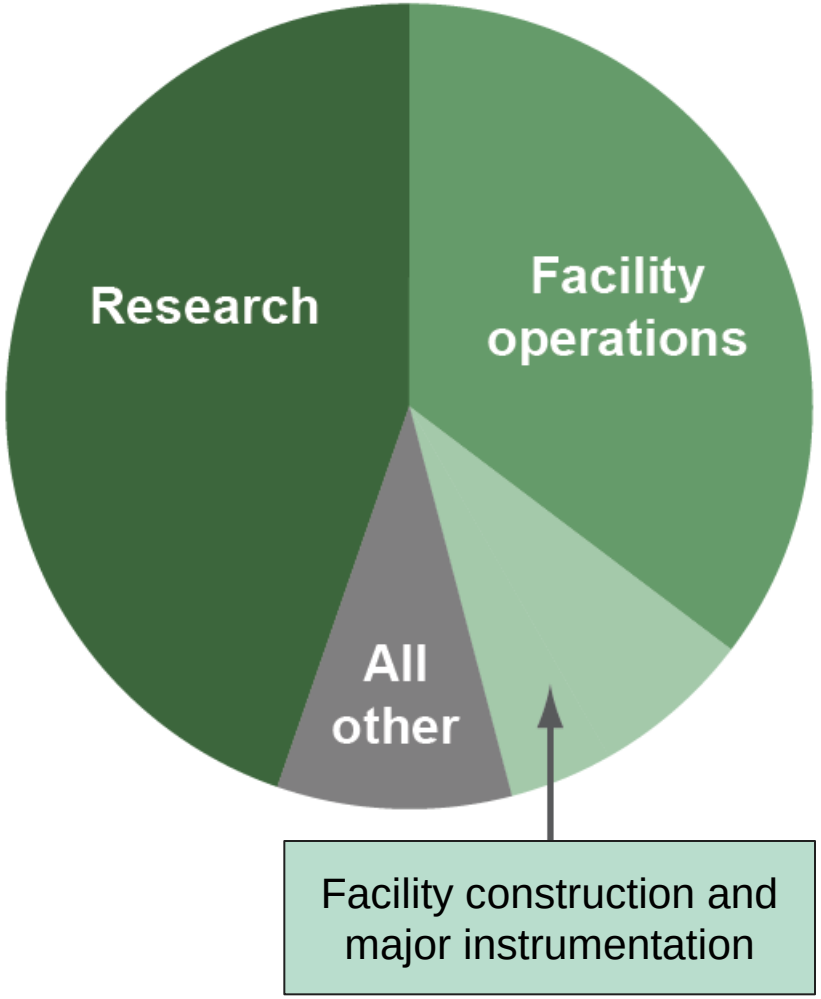
21st Century Tools of Science

- Providing the world's largest collection of scientific user facilities to over 29,000 users each year

SC touches more people through its user facilities than it does through direct funding

Office of Science Budget by Research & Facilities

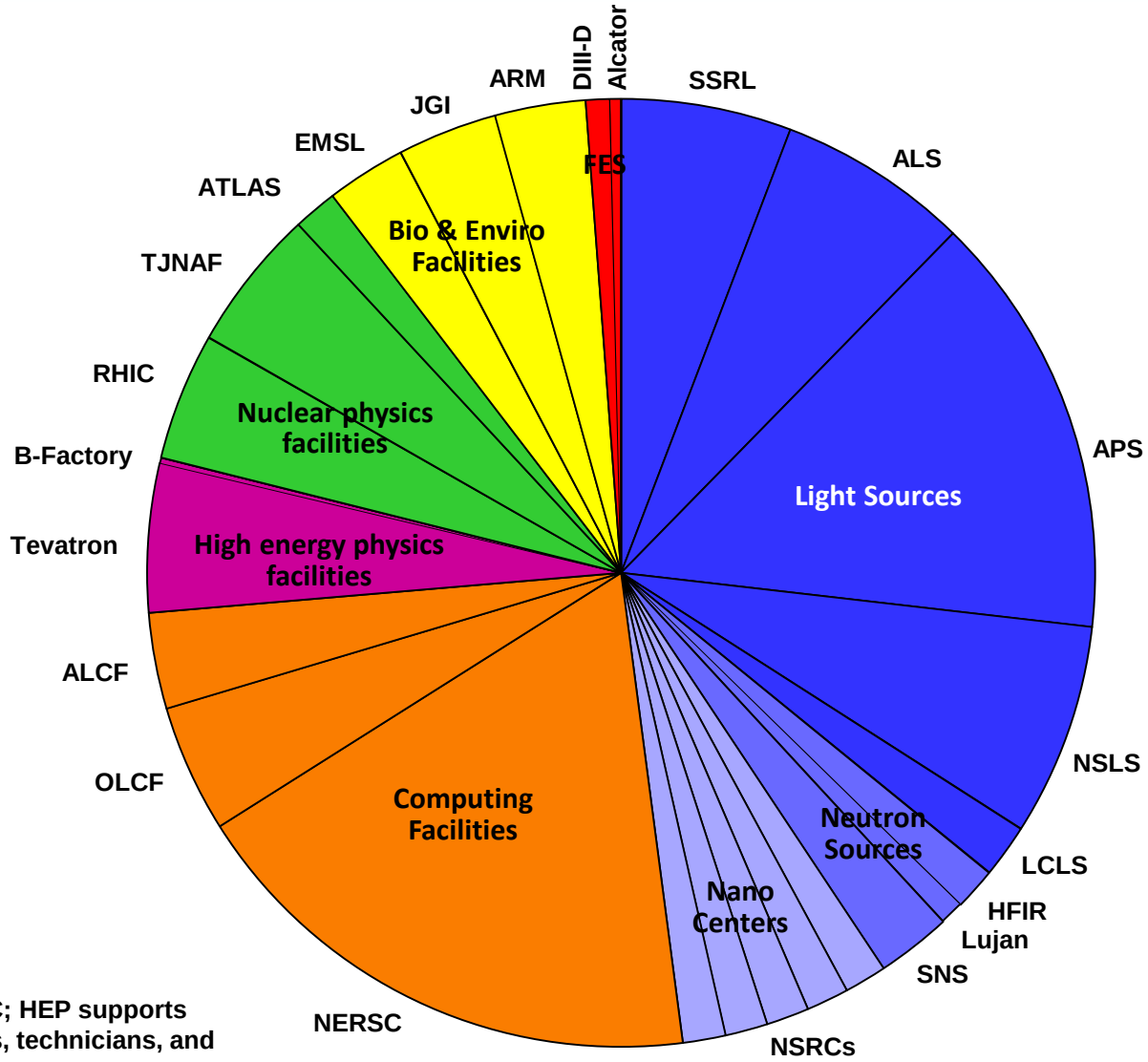
>40% of SC funding is provided to the scientific user facilities



User facilities address needs of the scientific community not met by other government agencies, public organizations, private entities, or international bodies.

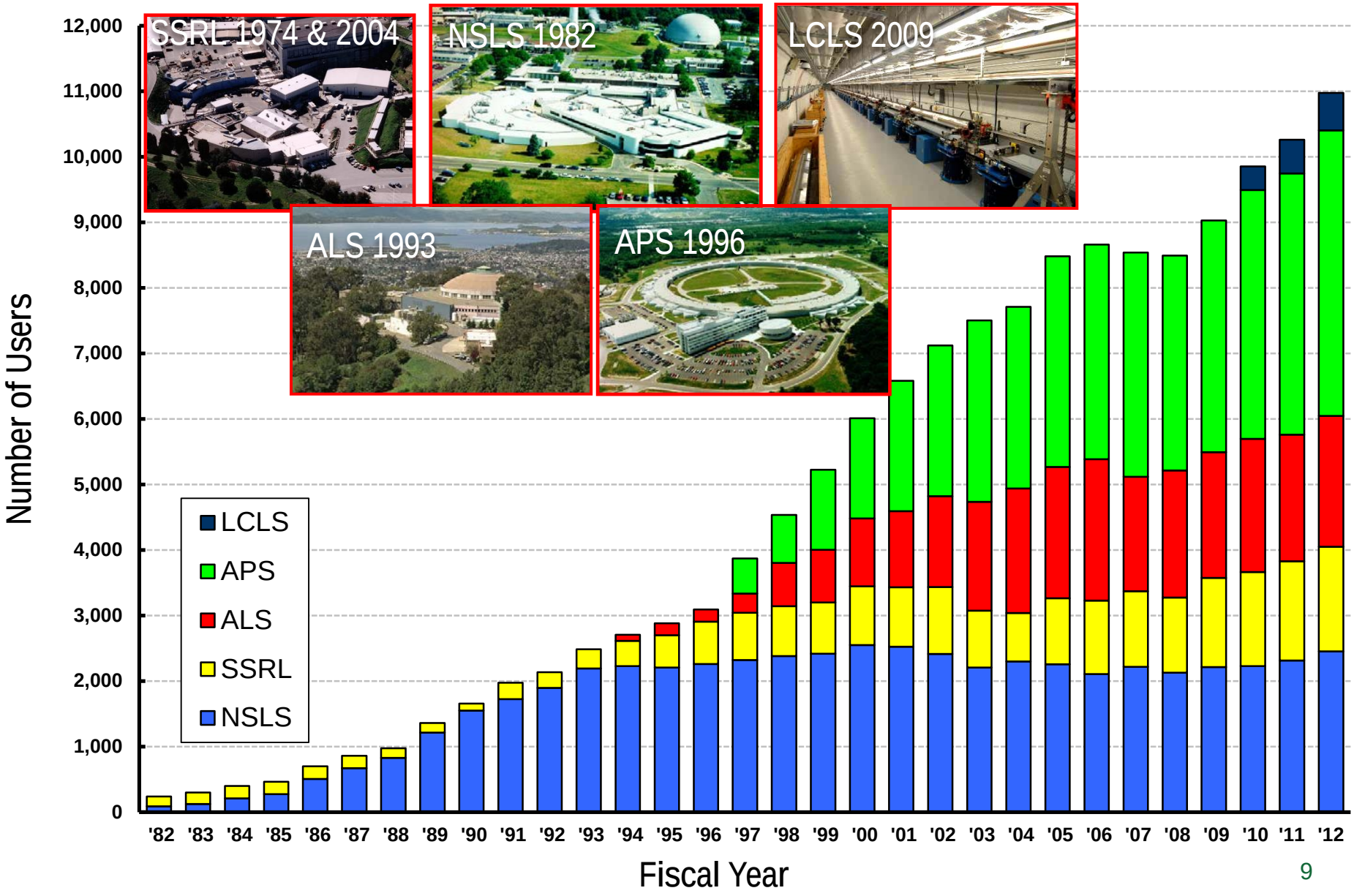
Distribution of Users at the ~30 SC Facilities

Nearly ¾ of users do their work at ASCR or BES facilities

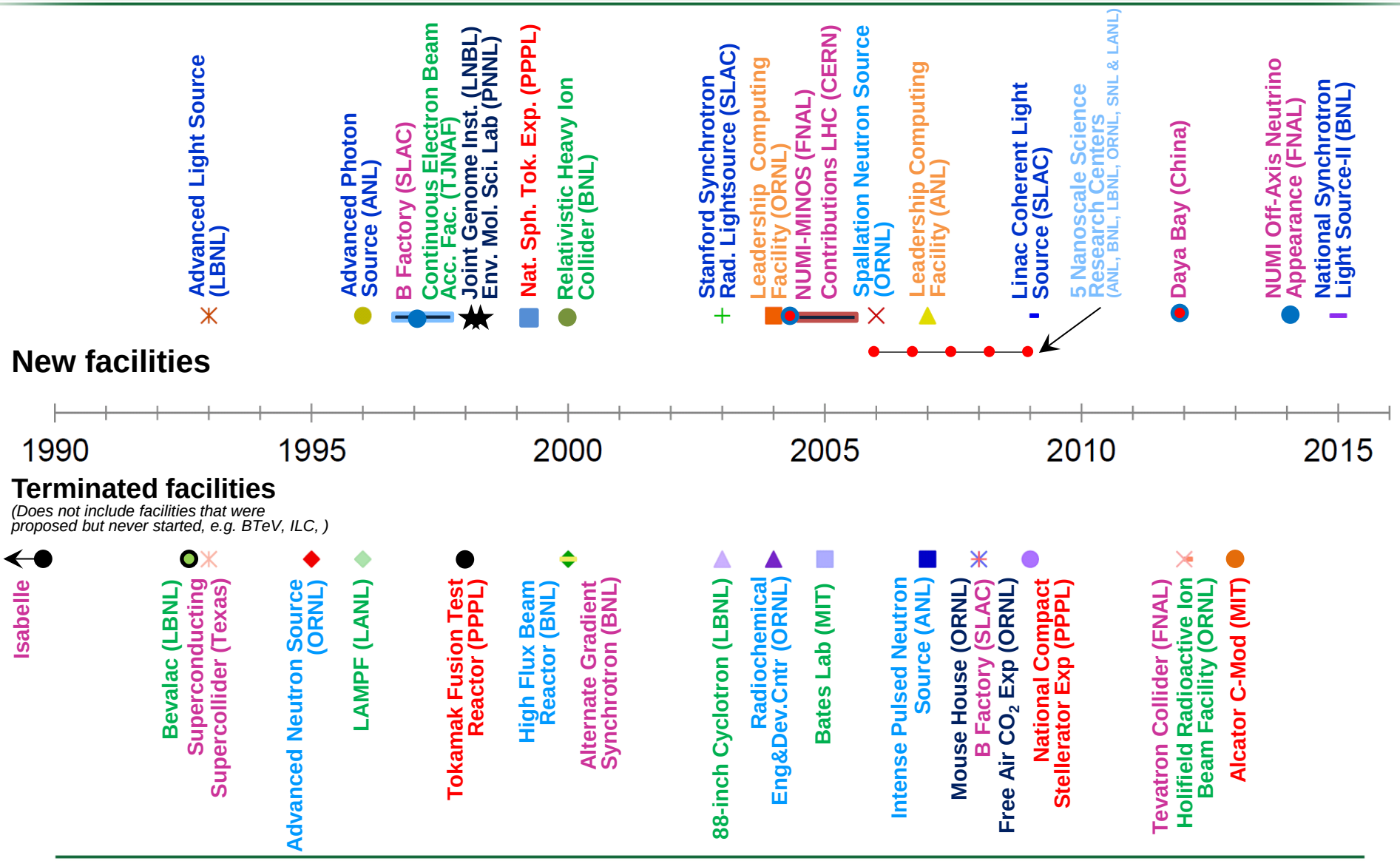


Does not include LHC; HEP supports about 1,700 scientists, technicians, and engineers at the LHC.

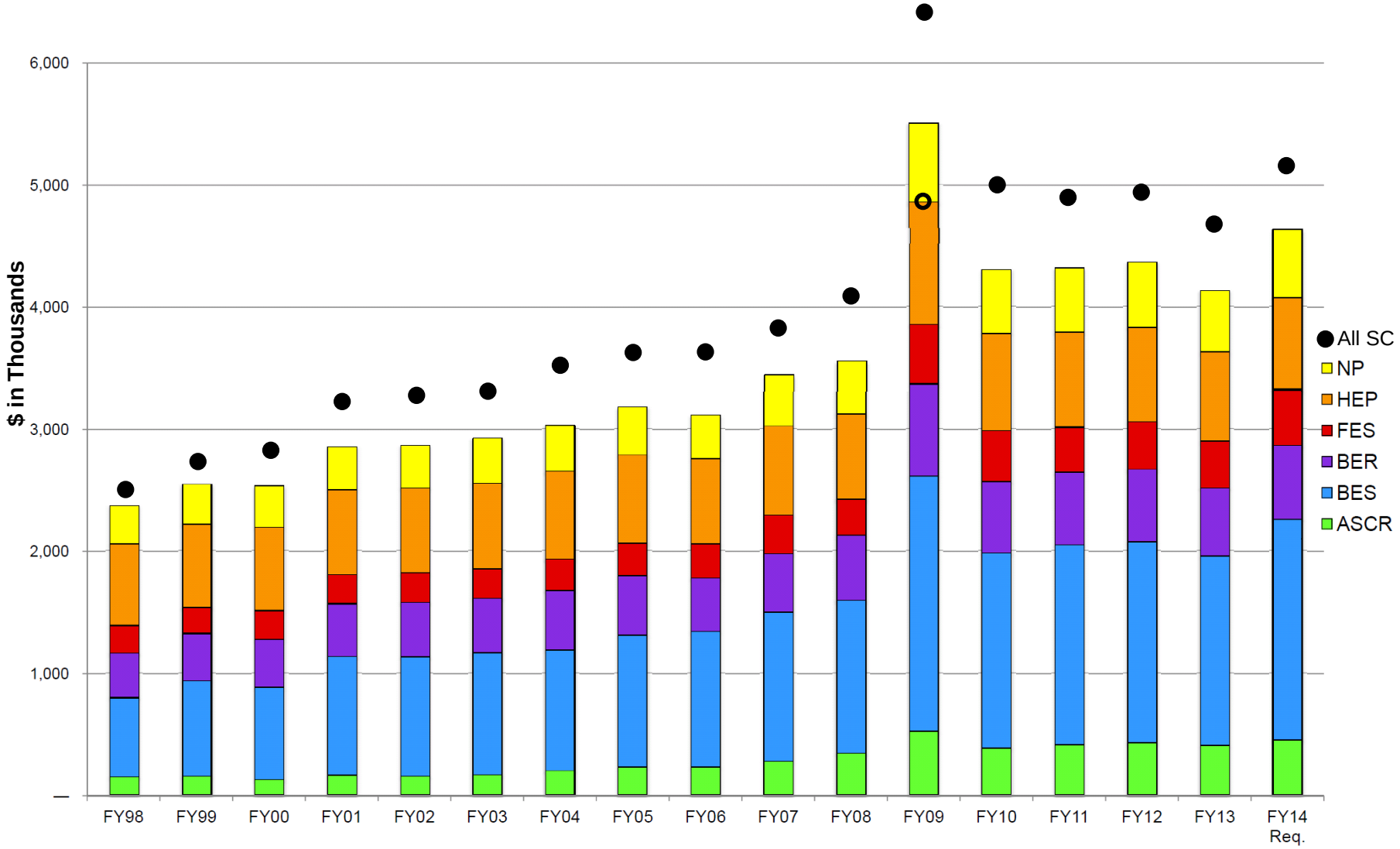
Users by Facility at the Light Sources



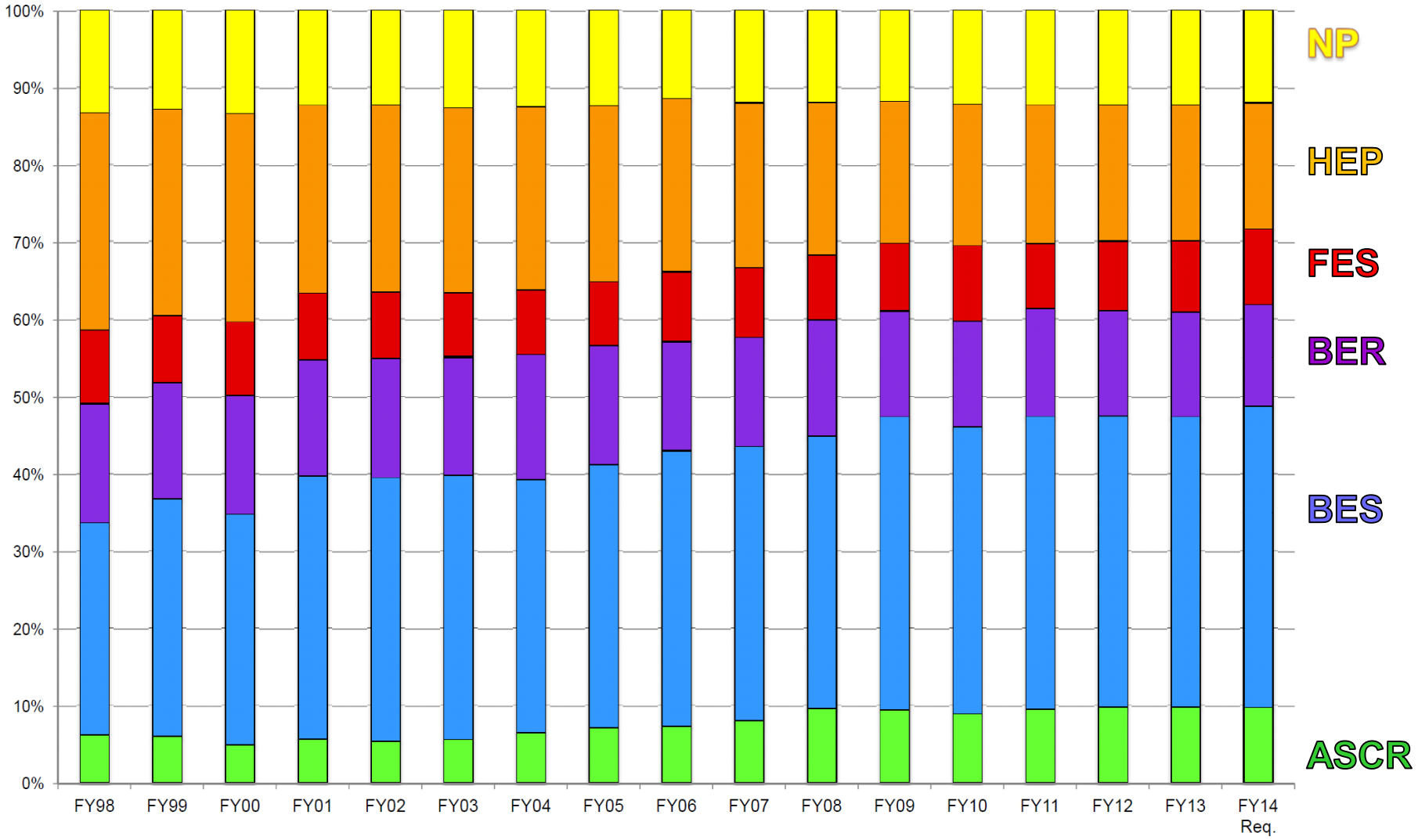
A Summary of Terminated and New Major Facilities 1990-2015



Office of Science Funding FY 1996-2014



Major SC Program Funding (% of total) FY 1996-2014



Facilities for the Future of Science: A 20-year Outlook (November 2003)

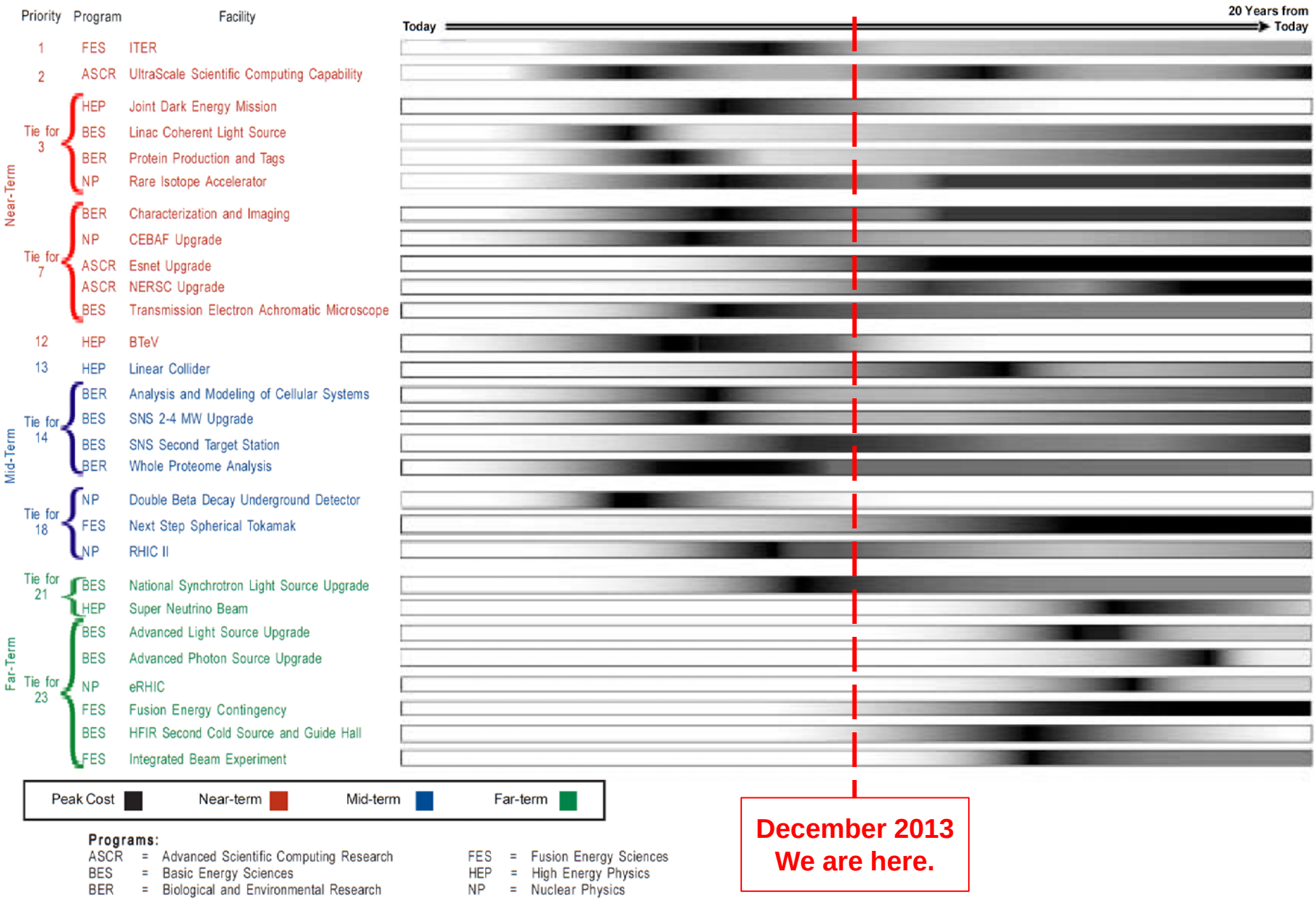
Facilities for the Future of Science (2003)

Paraphrasing FFS, “Today, the Department of Energy is building the Spallation Neutron Source, the last large-scale SC user facility under construction. And that raises the question that *Facilities for the Future of Science: A Twenty-Year Outlook* addresses*:* What facilities are needed next for scientific discovery?”

Funding envelopes were constructed from the “Biggert Bill” authorization levels for SC for
FY 2004 through FY 2008 (replaced later by H.R. 6 and S. 14) and then a four percent increase in authorization level each following year until 2023.

H.R. 34, the "Energy and Science Research Investment Act of 2003,” aka the Biggert Bill, authorized an increase in funding for SC of ~60% from FY 2004 through FY 2007. The bill called for an increase of ~8% for FY 2004 followed by increases of 11%, 15%, and 15% in the following three years. The FY 2007 authorization level would have been $5.31 B.

U.S. Department of Energy Office of Science 20-Year Facility Outlook Peak of Cost Profile



Programs:

ASCR = Advanced Scientific Computing Research
BES = Basic Energy Sciences
BER = Biological and Environmental Research
FES = Fusion Energy Sciences
HEP = High Energy Physics
NP = Nuclear Physics

December 2013
We are here.


Priority
Program
Facility
1 FES ITER .....Yes; ITER is underway
2 ASCR UltraScale Scientific Computing Capability .....Yes; ANL and ORNL LCFs complete and are already upgraded
Near-Term
Tie for 3
HEP Joint Dark Energy Mission .....No; terminated
BES Linac Coherent Light Source .....Yes; complete, awaiting Congressional approval for upgrade
BER Protein Production and Tags .....No; replaced with BRCs, which are not user facilities
NP Rare Isotope Accelerator .....Yes; replaced with less expensive FRIB, awaiting Congressional start
Tie for 7
BER Characterization and Imaging .....No; replaced with BRCs, which are not user facilities
NP CEBAF Upgrade .....Yes; upgrade in progress
ASCR Esnet Upgrade .....Yes; complete
ASCR NERSC Upgrade .....Yes; complete
BES Transmission Electron Achromatic Microscope ...Yes; complete
12 HEP BTeV .....No; terminated
13 HEP Linear Collider .....No; terminated
Mid-Term
Tie for 14
BER Analysis and Modeling of Cellular Systems .....No; replaced with BRCs, which are not user facilities
BES SNS 2-4 MW Upgrade .....No; power upgrade will be included in 2nd Target Station
BES SNS Second Target Station .....No; past CD-0 but cost precludes near-term start
BER Whole Proteome Analysis .....No; replaced with BRCs, which are not user facilities
Tie for 18
NP Double Beta Decay Underground Detector .....Partially; Majorana demonstrator operating, but not yet full exp
FES Next Step Spherical Tokamak .....No, NSTX upgrade was pursued following NCSX termination due to cost overruns
NP RHIC II ..... Yes, luminosity upgrade complete at a fraction of the cost & within operating budget
Tie for 21
BES National Synchrotron Light Source Upgrade ...Yes, NSLS-II will commission in FY 2014
HEP Super Neutrino Beam .....Partially; NOνA is near complete, but not yet LBNE
Far-Term
Tie for 23
BES Advanced Light Source Upgrade .....No
BES Advanced Photon Source Upgrade .....Partially; APS-U has R&D funding
NP eRHIC .....No
FES Fusion Energy Contingency .....No
BES HFIR Second Cold Source and Guide Hall .....No
FES Integrated Beam Experiment .....No

“Prioritization of Scientific Facilities to Ensure Optimal Benefit from Federal Investments” (October 2013)

FY2012-2013 SC Priority Goal
From OMB to DOE/SC

Prioritization of scientific facilities to ensure optimal benefit from Federal investments. By September 30, 2013, formulate a 10-year prioritization of scientific facilities across the Office of Science based on (1) the ability of the facility to contribute to world-leading science, (2) the readiness of the facility for construction, and (3) an estimated construction and operations cost of the facility.

Steps in Addressing the Priority Goal

- Funding levels allowed the SC Associate Directors some flexibility but did not permit the growth seen in the Biggert Bill. It is recognized that even COL growth may be optimistic.
- The ADs prepared draft lists of facilities needed for scientific leadership in their programs to 2024. In general, upgrades or new facilities were >$100M.
- Lists were submitted to the respective Federal Advisory Committees, which could add facilities at their discretion. They were asked to rate each facility on:
  - The ability of the facility to contribute to world-leading science in one of these categories: *Absolutely Central*; *Important* ; *Lower priority*; or *Don't know enough yet*
  - The readiness of the facility for construction in one of these categories: *Ready to initiate construction*; *Scientific/engineering challenges to resolve before initiating construction*; or *Mission and technical requirements not yet fully defined*
- Facilities were grouped in bins, but they were not numerically ranked.
- This activity provides *input to decisions* on scientific priorities, i.e., it provides the financial impacts resulting from facility needs for the disciplines supported by SC.

Impacts of a Recent FACA (BESAC) Study

U.S. DEPARTMENT OF ENERGY | Office of Science

Snippets from:

BESAC Report on "Future X-Ray Light Sources" and the DOE Actions

Patricia Dehmer
Acting Director, Office of Science

Harriet Kung
Director, Office of Basic Energy Sciences

Jim Murphy
Director, BES Scientific User Facility Division

Charge to BESAC on X-ray Light Sources

- On January 2, 2013, Bill Brinkman, then the Director of the Office of Science, issued a charge to the Basic Energy Sciences Advisory Committee (BESAC).
- The charge requested:
  - An **assessment of the grand science challenges** that could best be explored with current and possible future SC light sources.
  - An **evaluation of the effectiveness of the present SC light source portfolio** to meet these grand science challenges.
  - An **enumeration of future light source performance specifications** that would maximize the impact on grand science challenges.
  - **Prioritized recommendations** on which future light source concepts and the technology behind them are best suited to achieve these performance specifications.
  - Identification of **prioritized research and development initiatives** to accelerate the realization of these future light source facilities in a cost effective manner.
- John Hemminger, the Chair of BESAC, served as Chair of a 22 member Subcommittee, which used previous BESAC and BES reports and new input from the x-ray sciences communities to formulate findings and recommendations.
- The final report was accepted by BESAC on July 25, 2013.

BESAC – Findings

- At the present time, the U.S. enjoys a significant leadership role in the x-ray light source community. This is a direct result of the successes of the major facilities managed by BES for the U.S. This leadership position is due to the science successes of the storage ring facilities and the particularly stunning success of the first hard x-ray free electron laser, the Linac Coherent Light Source (LCLS). **However, it is abundantly clear that international activity in the construction of new diffraction limited* storage rings and new free electron laser facilities will seriously challenge U.S. leadership in the decades to come.**

- **The U.S. will no longer hold a leadership role in such facilities unless new unique facilities are developed** as recommended by the BESAC facilities prioritization report.

* *To upgrade an existing storage ring to one that is diffraction limited will require the replacement of the entire lattice to greatly reduce the electron source size and angular divergence in order to maximize the x-ray beam brightness.*

BESAC – Recommendations

- **For free electron lasers:** In spite of the present intensely competitive environment, an exciting window of opportunity exists for the U.S. to provide a revolutionary advance in x-ray science by developing and constructing an unprecedented x-ray light source. This new light source should provide **high repetition rate**, **ultra-bright, transform limited**, **femtosecond x-ray pulses** over a **broad photon energy range** with **full spatial and temporal coherence**. **Stability** and **precision timing** will be critical characteristics of the new light source.
  - The best approach for a light source would be a linac-based, seeded, free electron laser.
  - The linac should feed multiple, independently tunable undulators each of which could service multiple endstations.
  - The new light source must have pulse characteristics and high repetition rate to carry out a broad range of "pump probe" experiments, in addition to a sufficiently broad photon energy range (~0.2 keV to ~5.0 keV).

- **For storage rings:** At best the present plans for upgrades of U.S. storage rings will leave the U.S. behind the international community in this area of x-ray science. BES should ensure that U.S. storage ring x-ray sources reclaim their world leadership position. **This will require a careful evaluation of present upgrade plans to determine paths forward that will guarantee that U.S. facilities remain at the cutting edge of x-ray storage ring science.**

SC/BES Response to BESAC Recommendations

Project	Project status at the start of FY 2013, i.e., prior to receipt of BESAC report	Project status following receipt of BESAC report "Future X-Ray Light Sources" in July 2013
Linac Coherent Light Source II (LCLS-II), SLAC	Incorporate an additional 1 km of the existing 3 km linac; add a new electron injector; and 2 new undulators. Construct new tunnel and experimental hall.	SC asked SLAC to incorporate the BESAC recommendations into LCLS-II. SLAC proposed to add a superconducting linac in the existing tunnel and two new undulators to produce the world leading high rep rate FEL in the 0.2-5 keV photon energy range. No civil construction required.
LCLS-II Ultrafast Science Instruments (LUSI-II), SLAC	Provide 4-5 new instruments in the new experimental hall to make use of the 2 new undulator sources.	LUSI-II is not required in the modified LCLS-II proposal.
Advanced Photon Source Upgrade (APS-U), ANL	Upgrade of >20 beamlines; addition of new insertion devices; generation of 2 picosecond x-ray pulses; 50% increase in ring current.	SC asked ANL to incorporate diffraction limited storage ring technology into APS-U. ANL proposed a multi-bend achromat lattice in the existing tunnel; a doubling of the ring current; new insertion devices & beamlines to boost ring brightness.
Next Generation Light Source (NGLS), LBNL	High rep rate soft x-ray free electron laser facility based upon a superconducting linac and 3 undulators.	SC asked LBNL to consider whether NGLS could be modified at reasonable cost to include an expanded energy range. After consideration, LBNL terminated the NGLS project.