Future Challenges for Basic Energy Sciences User Facilities

Pedro A. Montano
Scientific User Facilities
Director

SUFD Organization,

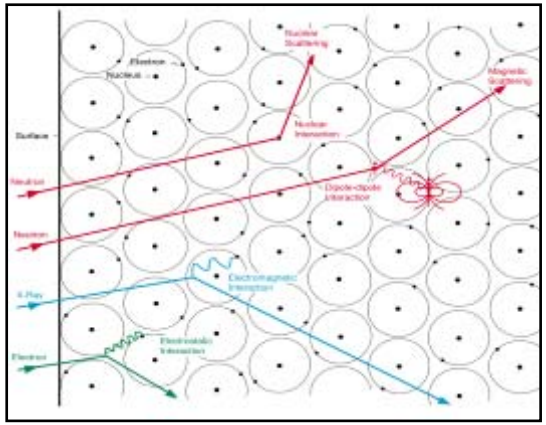
Operation

- X-Ray and Neutron Scattering Facilities
- Electron Scattering Facilities
- Nanoscale Science Research Centers
- Accelerator and Detector Research

Construction

- Linac Coherent Light Source
- SNS, LCLS, TEAM and X-ray and Neutron Scattering Instruments
- NSLS II

The BES Scientific User Facilities use x-rays, neutrons, and electrons as tools for characterization of materials



•Our understanding of properties of materials is based on knowledge of the structure and dynamical properties of the constituent atoms of the materials.

•Atoms are too small to be imaged directly, so we employ diffraction and scattering techniques to indirectly "image" the atoms. Because atoms are spaced ~0.2 nm apart, we employ radiation of a similar wavelength. The most widely used probes are beams of x-rays, neutrons, and electrons.

•X-ray and electron beams are very intense and readily available. Neutrons beams are much weaker; however, neutrons have very important properties that make them the ideal probe in many situations.

•The choice of which probe to use depends on the system under study and the information required.

•Today, the BES facilities for x-ray, neutron, NSRCs and electron-beam scattering serve thousands of scientists annually who perform research in materials sciences, physics, chemistry, geosciences, biosciences, and more. These facilities represent the largest such collection operated by a single organization in the world.

Interactions

- **The SUFD maintain very close interaction with all the programmatic divisions in BES. Observers from the programmatic divisions participate in the reviews of the neutron scattering facilities.**

- **There is active coordination between the SUFD and the programmatic divisions in the development and construction of new neutron scattering instrumentation.**

- **We have strong interaction with NNSA in dealing with the operation of LANSCE.**

- **There are significant interaction between our neutron facilities and international facilities like ISIS, JAEA and ISSP.**

- **There are instrumentation and user agreements between HFIR and JAEA/ISSP, SLAC and DESY/Spring-8, SNS and Canada, SNS and Germany.**

SUFD National Facilities

- **Light sources**
  - *Stanford Synchrotron Radiation Laboratory (SPEAR3)*
  - *National Synchrotron Light Source (BNL)*
  - *Advanced Light Source (LBNL)*
  - *Advanced Photon Source (ANL)*
  - *Linac at SLAC*
  - *Linac Coherent Light Source (SLAC) (under construction)*
  - *National Synchrotron Light Source II (BNL) (start construction in FY 2009)*

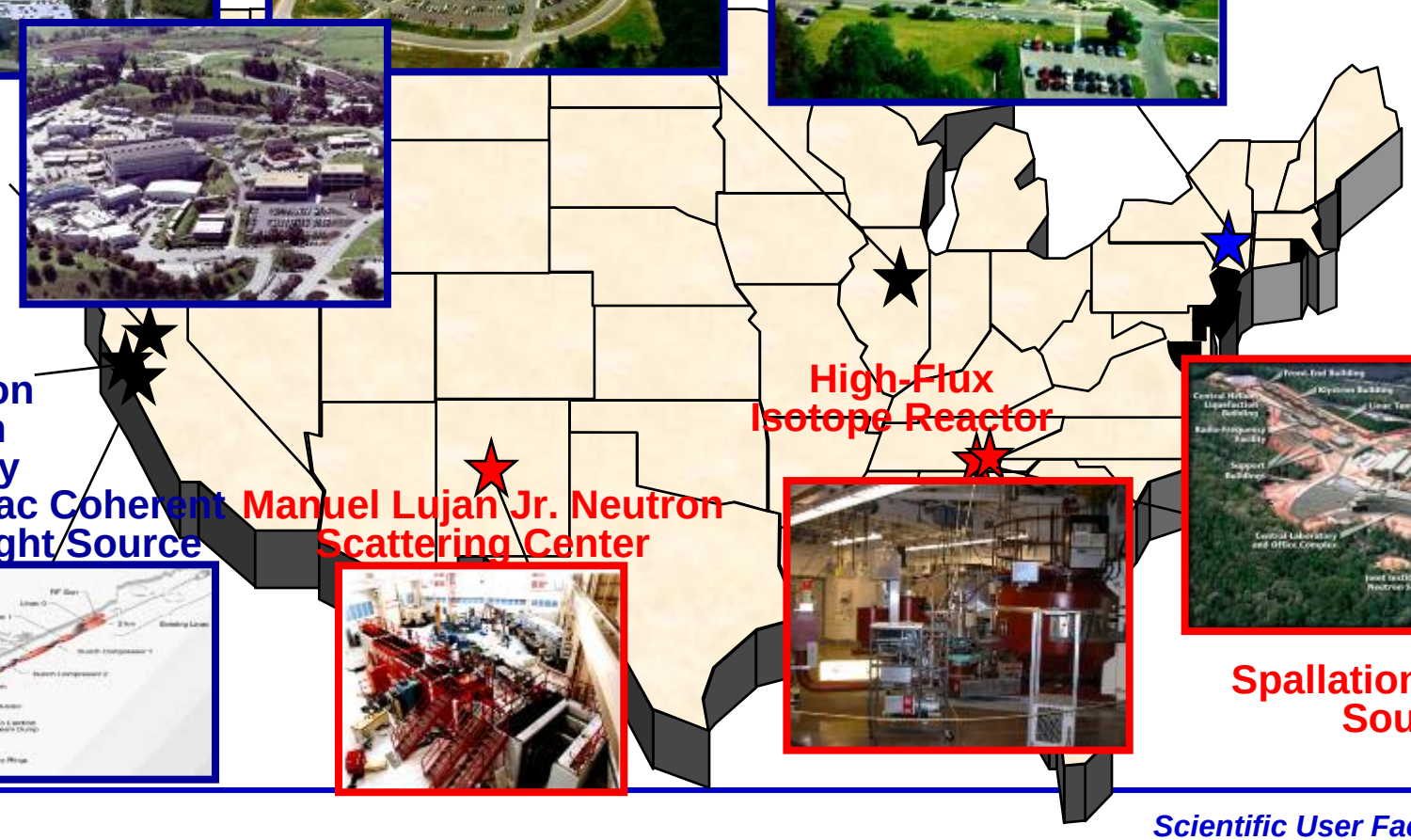
- **Neutron sources**
  - *Manuel Lujan, Jr. Neutron Scattering Center (LANL)*
  - *High Flux Isotope Reactor (ORNL)*
  - *Spallation Neutron Source (ORNL)*
- **Electron beam sources**
  - *Electron Microscopy Center for Materials Research (ANL)*
  - *National Center for Electron Microscopy (LBNL)*
  - *Shared Research Equipment Program (ORNL)*
- **Nanoscale Science Research Centers**
  - *Center for Nanophase Materials Sciences (ORNL)*
  - *Molecular Foundry (LBNL)*
  - *Center for Integrated Nanotechnologies (SNL & LANL)*
  - *Center for Functional Nanomaterials (BNL)*
  - *Center for Nanoscale Materials (ANL)*

BES Facilities for X-ray and Neutron Scattering

Advanced Light Source

Advanced Photon Source

National Synchrotron Light Source



Types of Users

» **General Users**

» **Partner Users**

» **Proprietary Users**

» ***Remote Users***

Remote User

- Operate Instrument Remotely
- Send Samples and Analyze Data
- Other (e.g. institutions that receive products)

General Users Access Policy

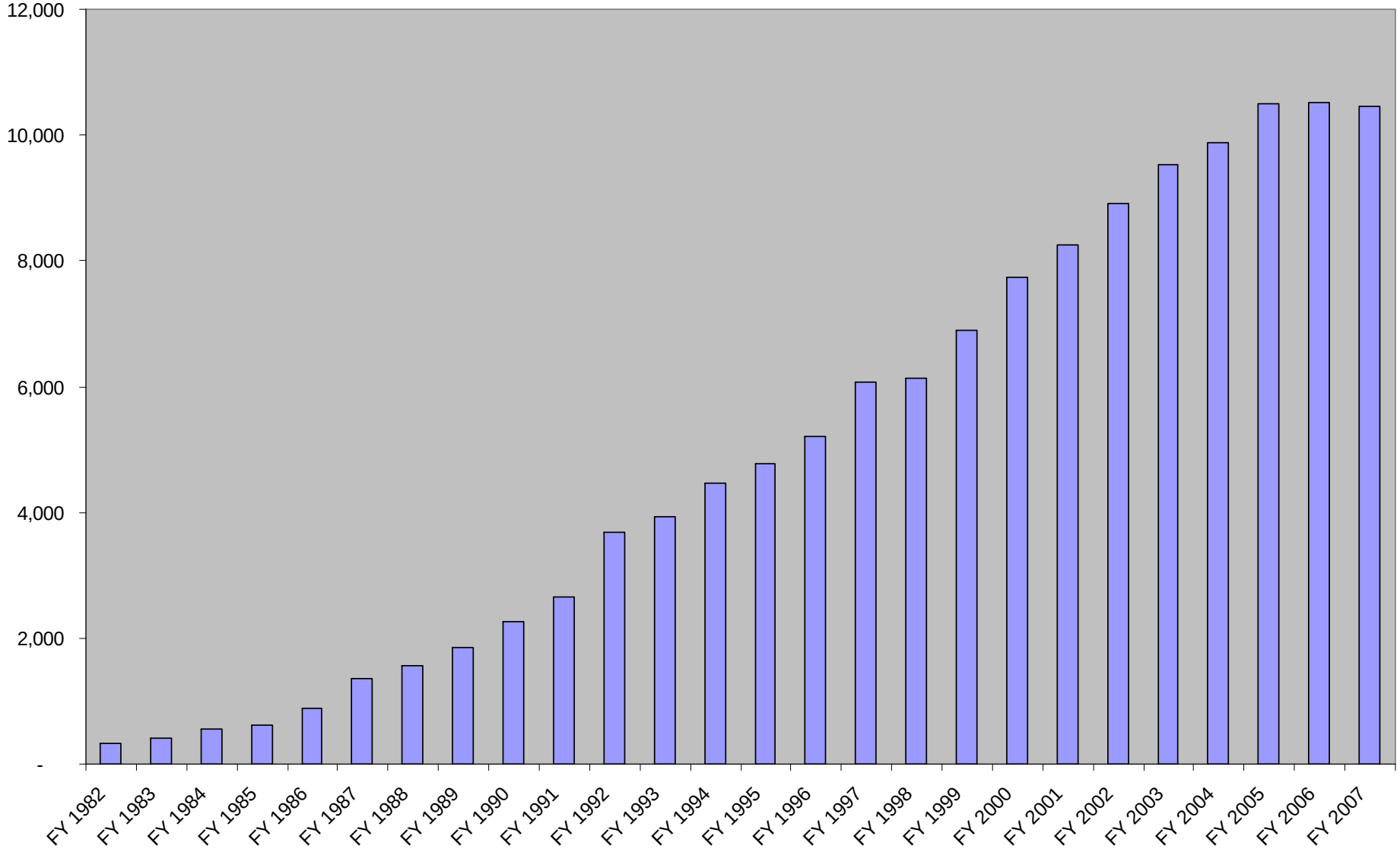
- *Access based on peer merit review of submitted proposal, evaluated by external Proposal Review Committee or equivalent*
- *Includes on-site (badged), remote, and off-site users*
- *Partner Users*
  - *Access based on peer merit review of submitted proposal, evaluated by external Proposal Review Committee and/or by Scientific Advisory Committee*
  - *Enhance capabilities of and/or contribute to operation of facility, with benefits to the general user community*
  - *Defined and limited period of reserved time or preferential access*
- *Large majority of time must remain available to general users*
- *A very limited amount of time may be allocated directly at the discretion of the NSRC Director or management for rapid access*
- *Collaboration with facility scientists is an important potential benefit to users, but is not required. Facility staff may provide input on feasibility and time needed but do not select or approve proposals.*

Model of Operation of Instruments and Beamlines
Spallation Neutron Source – User Access Policy

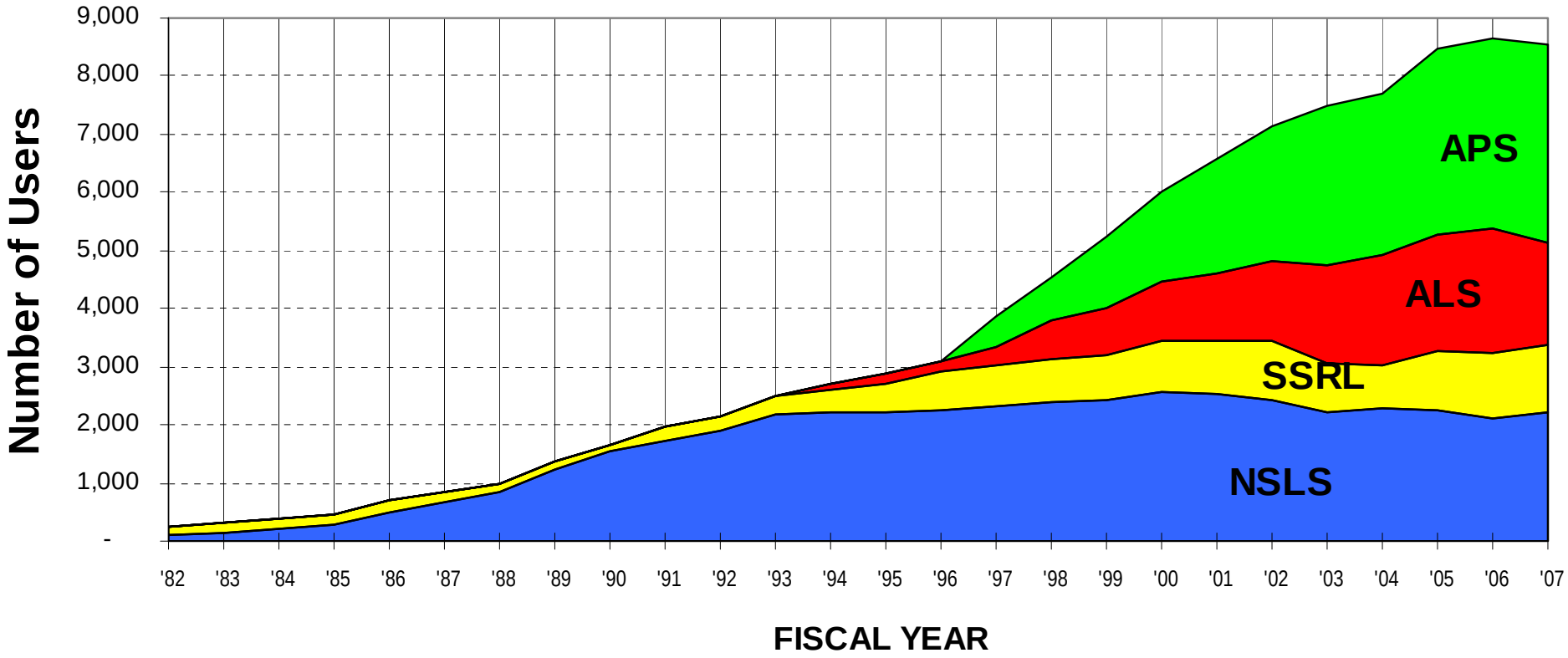
- Time available to General Users (GU) is maximized.
- Users participate in instrument specification, design, and fabrication through:
  - Instrument Advisory Teams (IATs) that work with SNS to provide input into the design and scientific program of each SNS project funded instrument.
  - Instrument Development Teams (IDTs) that work with SNS to obtain instruments that are funded outside of the SNS construction project. IDTs advise SNS on the conceptual design and construction of an instrument and are responsible for ensuring that the scientific requirements of the GU community are met.
- Both IAT and IDT instruments will have the majority of their beam-time (>80%) allocated for the General User community through peer review of scientific proposals.
- DOE/BES will provide funds to operate the neutron source, most of the instruments regardless of how they are capitalized, and user support facilities.

All research is peer reviewed.

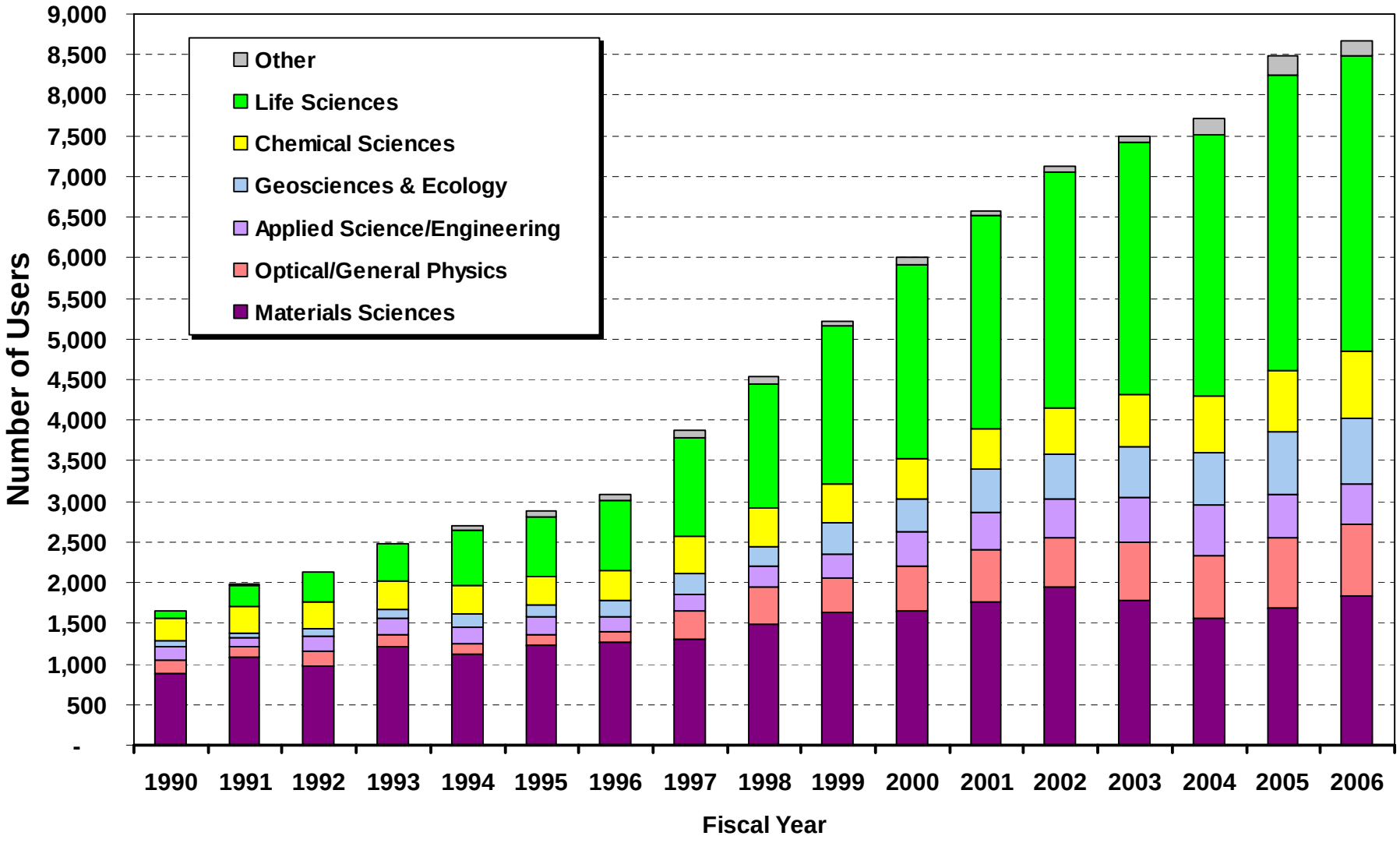
BES unique users at all facilities



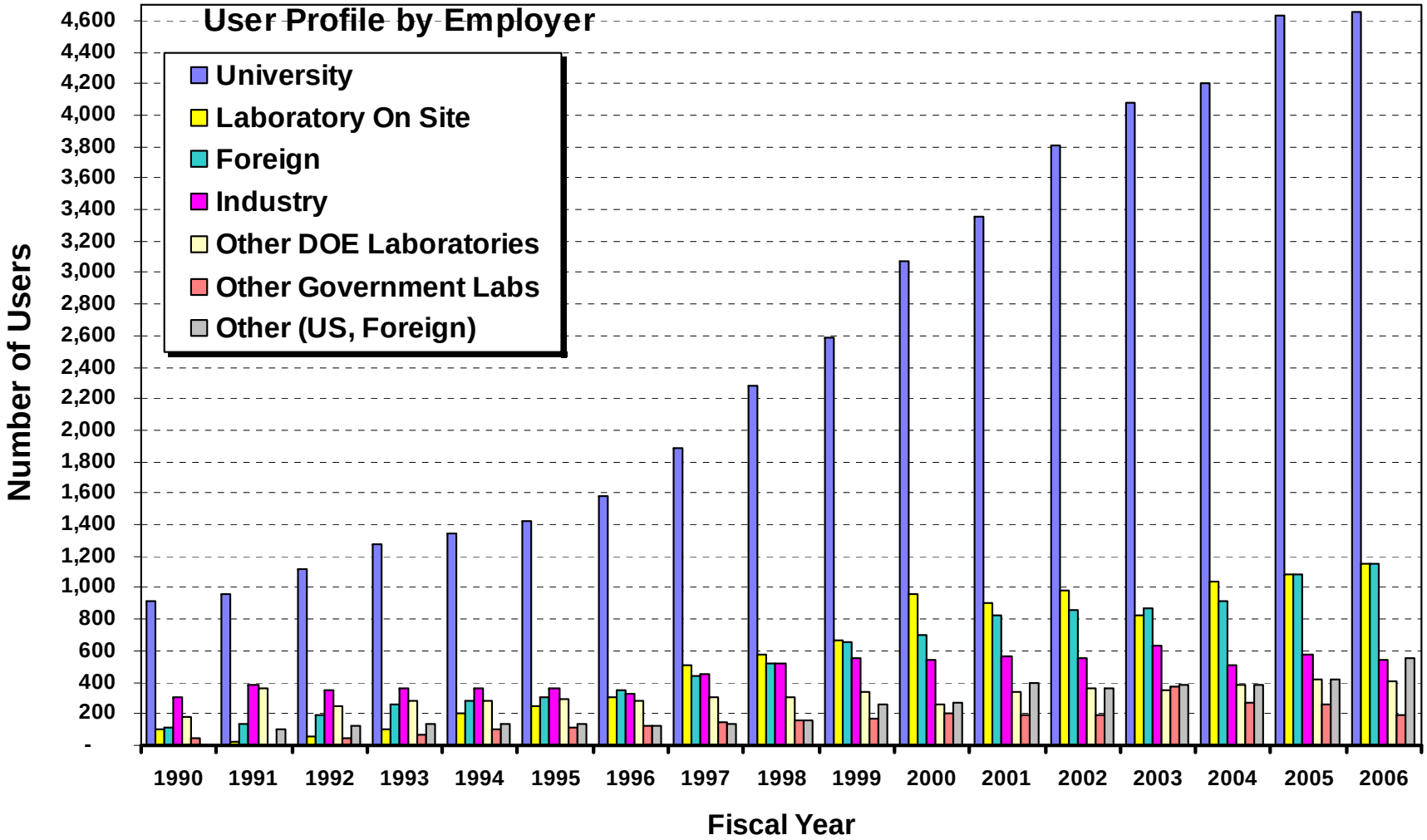
Users of Synchrotron Radiation Facilities



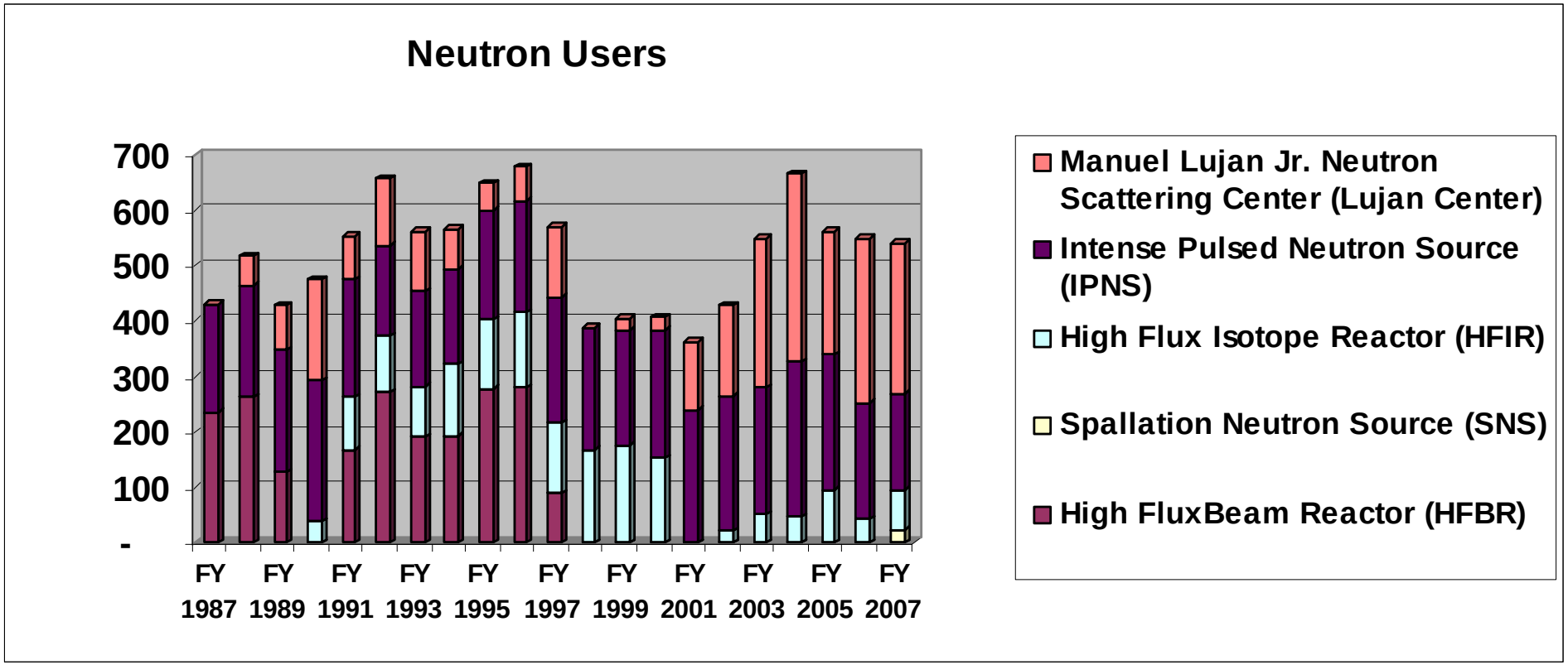
Light sources users by discipline



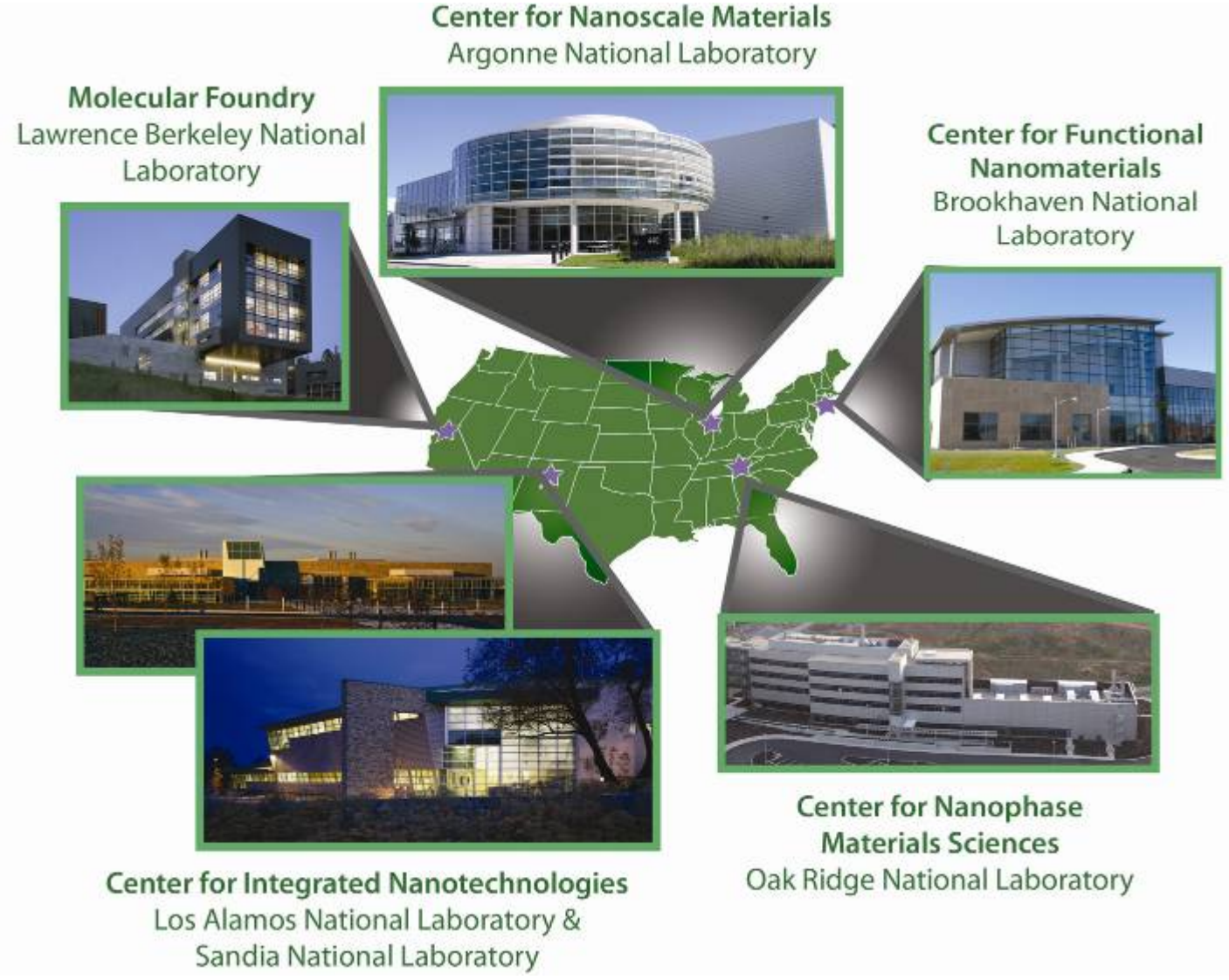
Four BES Light Sources



Neutron Scattering Users at BES Facilities

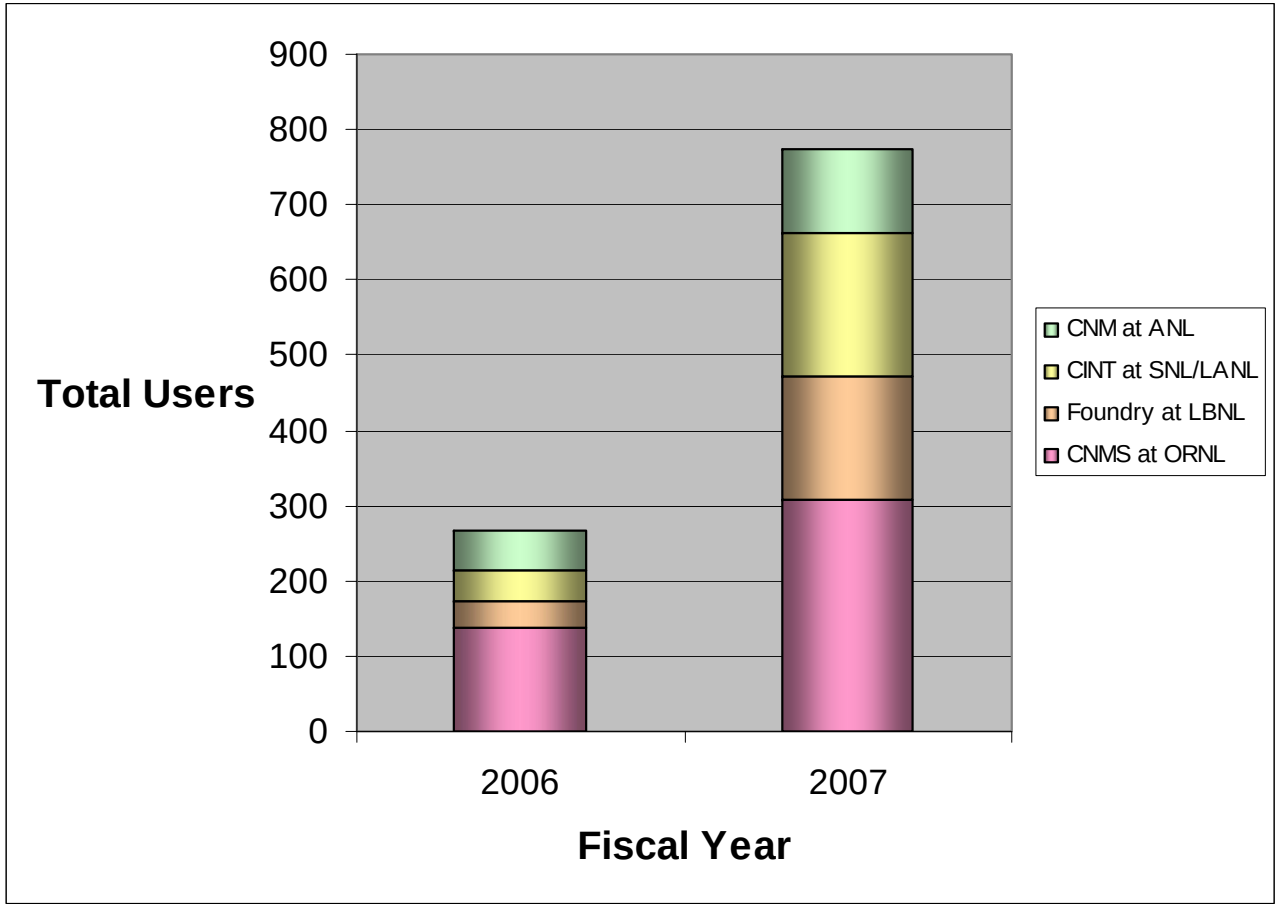


NSRCs


Center for Nanoscale Materials
Argonne National Laboratory
Molecular Foundry
Lawrence Berkeley National Laboratory
Center for Functional Nanomaterials
Brookhaven National Laboratory
Center for Nanophase Materials Sciences
Oak Ridge National Laboratory
Center for Integrated Nanotechnologies
Los Alamos National Laboratory &
Sandia National Laboratory

User statistics to date

Numbers of unique users, including badged users, remote users, and, starting FY 2007, off-site users. FY 2006 data is partial-year as three NSRCs began operations in mid-FY. Totals, FY 2007:



- ***Badged Users: 626***
- ***Remote Users: 40***
- ***Off-Site Users: 108***

Operational reviews

The Facilities are reviewed every three years.

- **The BES objective is to produce the best science possible at our facilities.**
- **The user community should have access to the facility using a proposal evaluation system that is fair and stimulate the performance of high quality research.**
- **The resources provided to the facilities should be used to optimize its utilization as well as the development of new and better techniques for the user community.**

Reviews of BES Facilities

Facilities are reviewed using (1) external, independent review committees operating according to the procedures established for peer review of BES laboratory programs and facilities (http://www.science.doe.gov/bes/labreview.html) or (2) subcommittees of BESAC.

BESAC subcommittees have reviewed the synchrotron radiation light sources, the neutron scattering facilities, and the electron-beam micro characterization facilities.

Regardless of whether a review is by an independent committee charged by BES or by a BESAC subcommittee, the review has standard elements. Important aspects of the reviews include assessments of the quality of research performed at the facility; the reliability and availability of the facility; user access policies and procedures; user satisfaction; facility staffing levels; R&D activities to advance the facility; management of the facility; and long-range goals of the facility.

These reviews have identified best practices and substantive issues. For example, the reviews highlighted the change that occurred as the light sources transitioned from a mode in which they served primarily expert users to one in which they served very large numbers of inexperienced users in a wide variety of disciplines.

Facilities that are in design or construction are reviewed according to procedures set down in DOE Order 413.3 *Program and Project Management for Capital Assets* and in the Office of Science *Independent Review Handbook*. These Office of Science construction project reviews, enlist experts in the technical scope of the facility under construction and its costing, scheduling, and construction management.

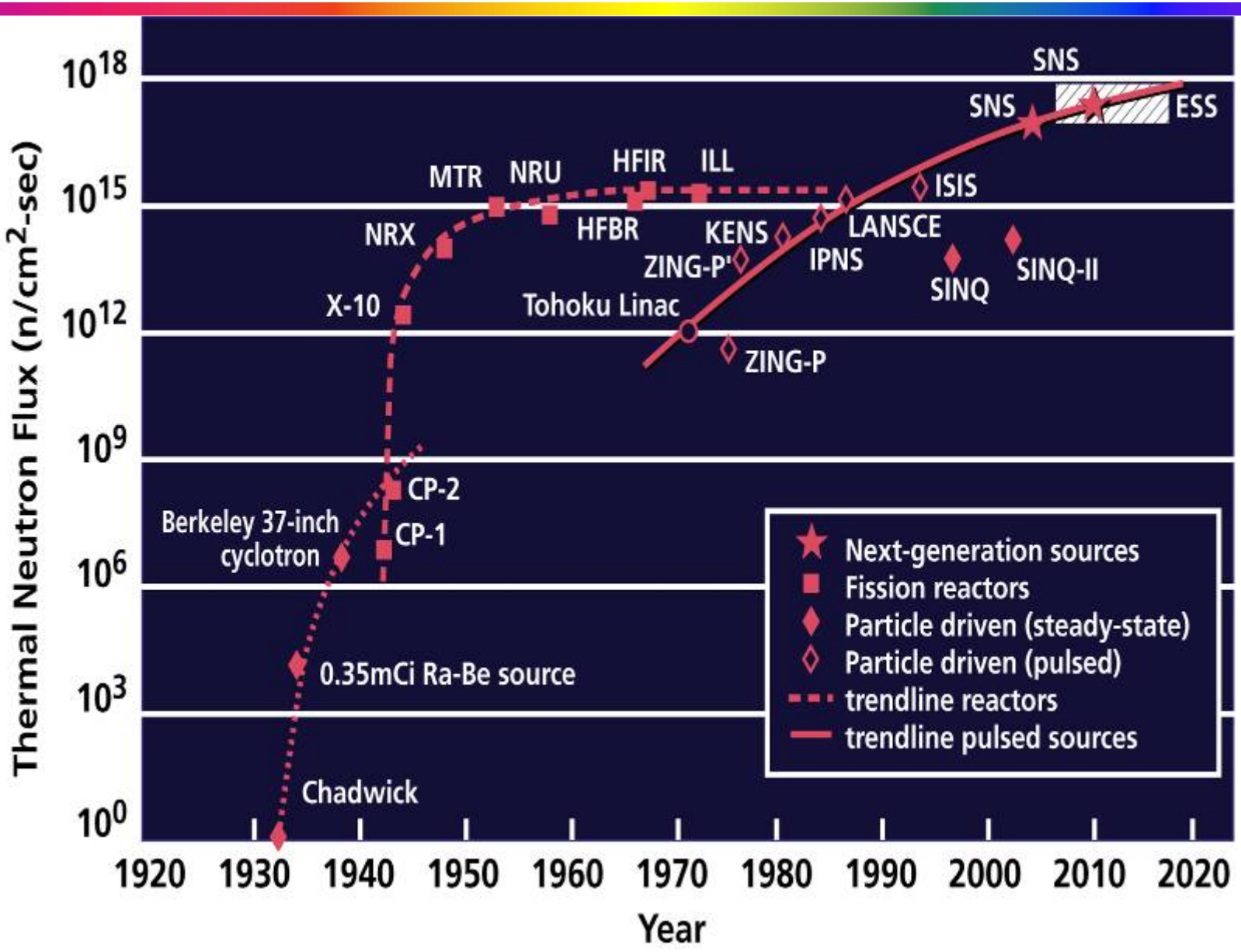
Topics covered in the review:

1. **Facility performance (schedules, users participation, etc)**
2. **Selected presentations of the most outstanding research performed at the Facility during the last two years (by field of research)**
3. **R&D plans and future scientific directions**
4. **Laboratory plans that may affect the Facility**

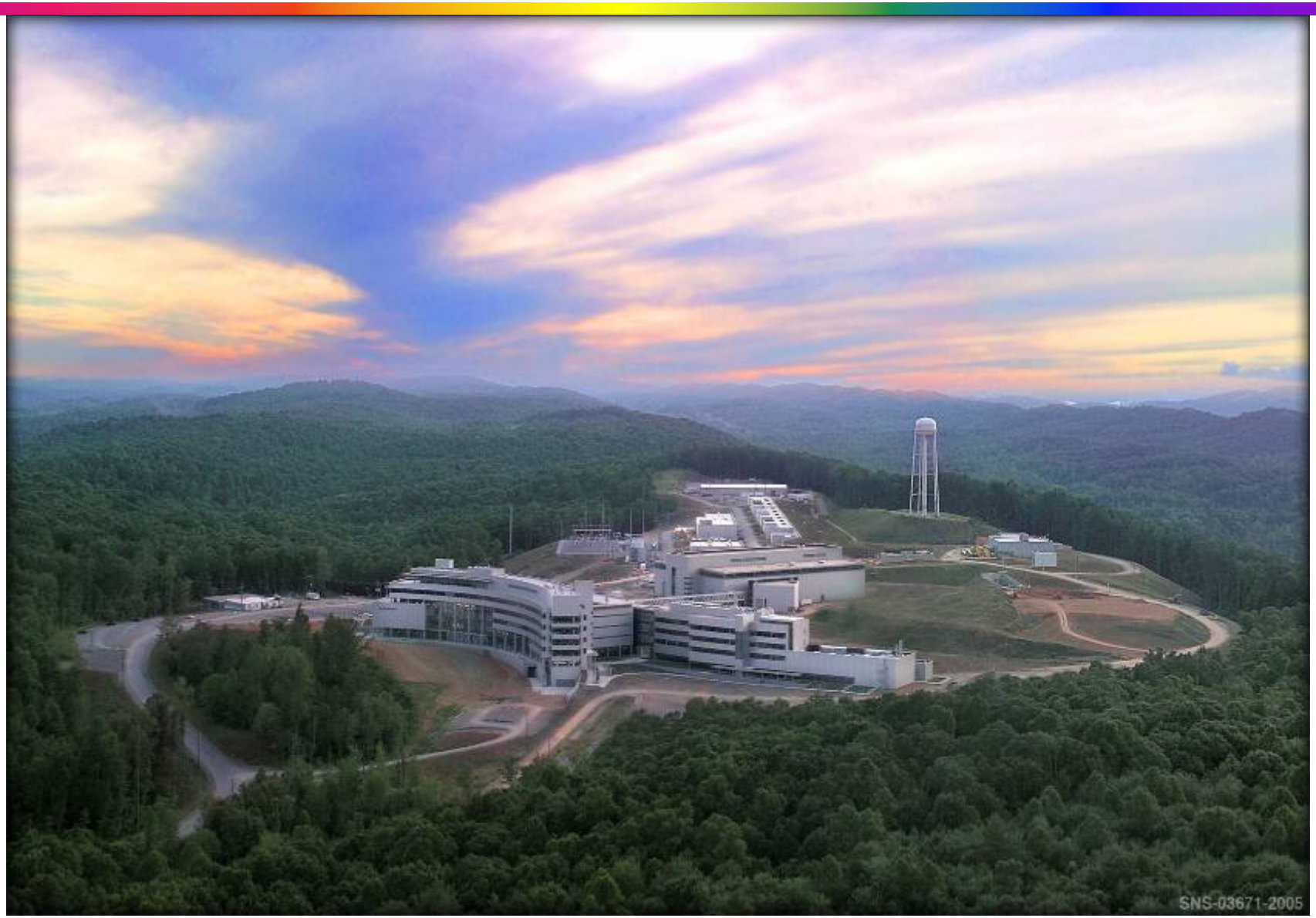
The schedule should include time for the reviewers to meet individually with the facility scientific staff in their focus areas and additional areas of interest. A focus session with representatives of the users community without the laboratory management presence. The agenda and logistics for the review is coordinated with BES.

New Facilities Under Construction

Evolution of Neutron Beam Sources

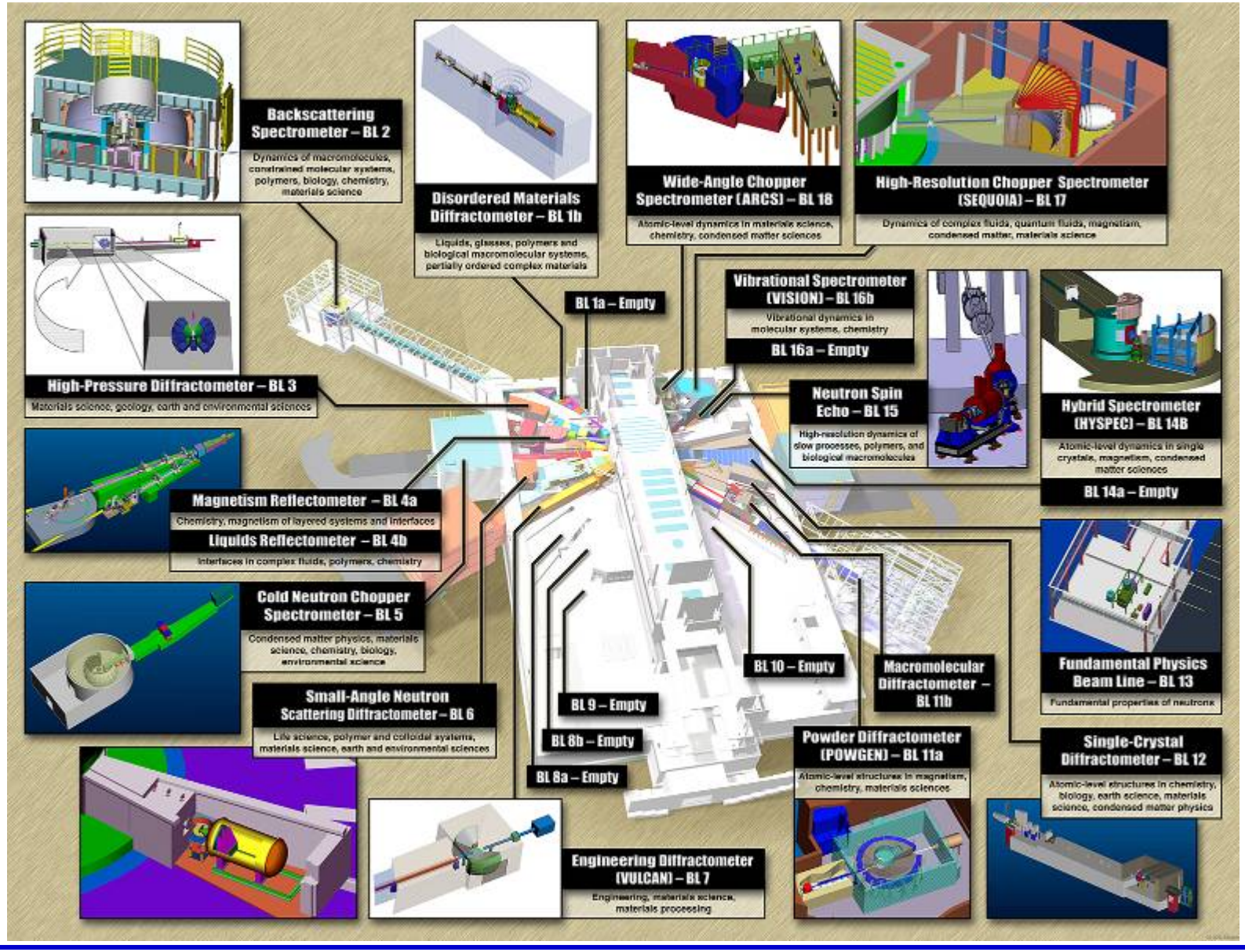


The Spallation Neutron Source

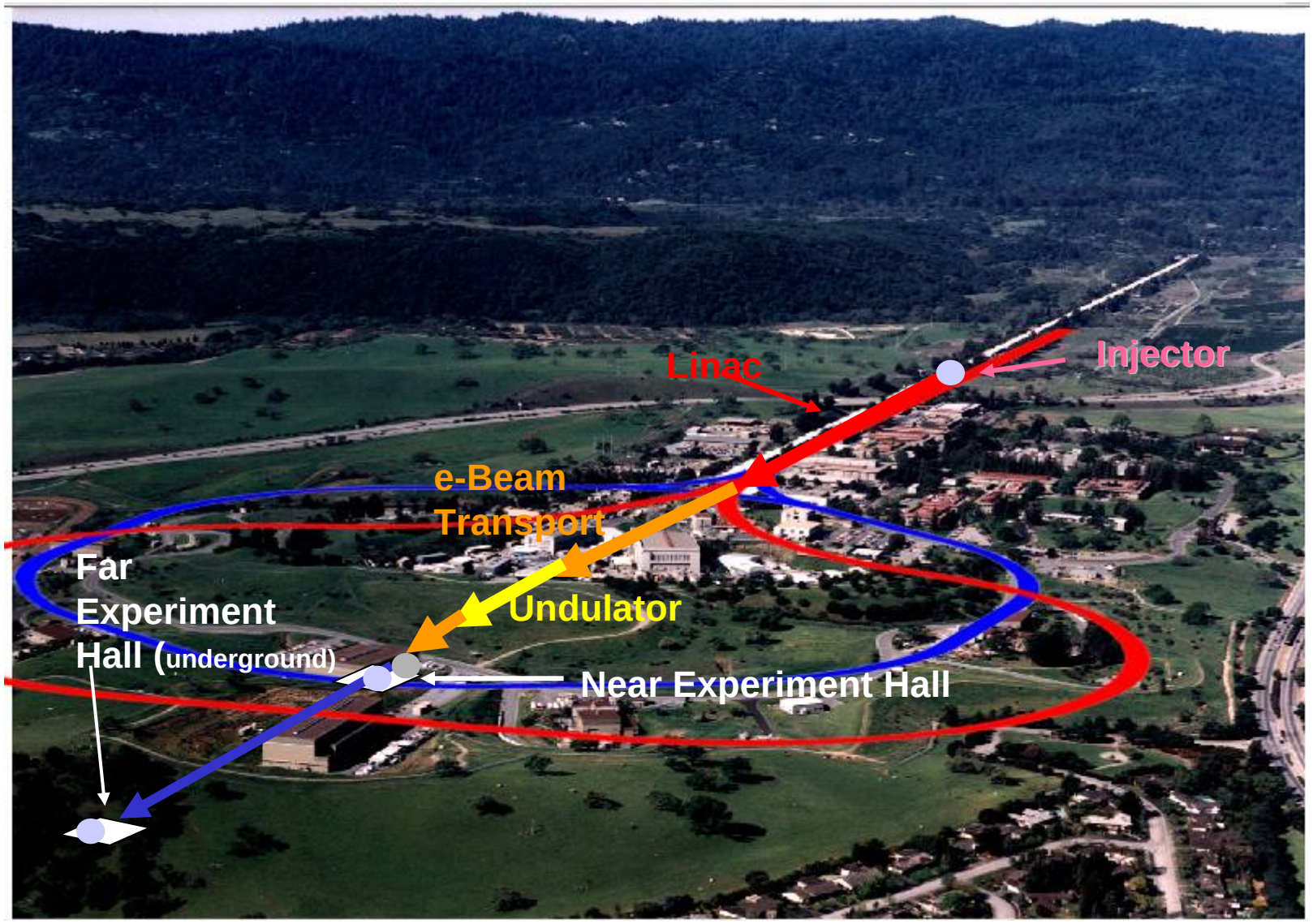


Spallation Neutron Source
(Construction completed 2006)

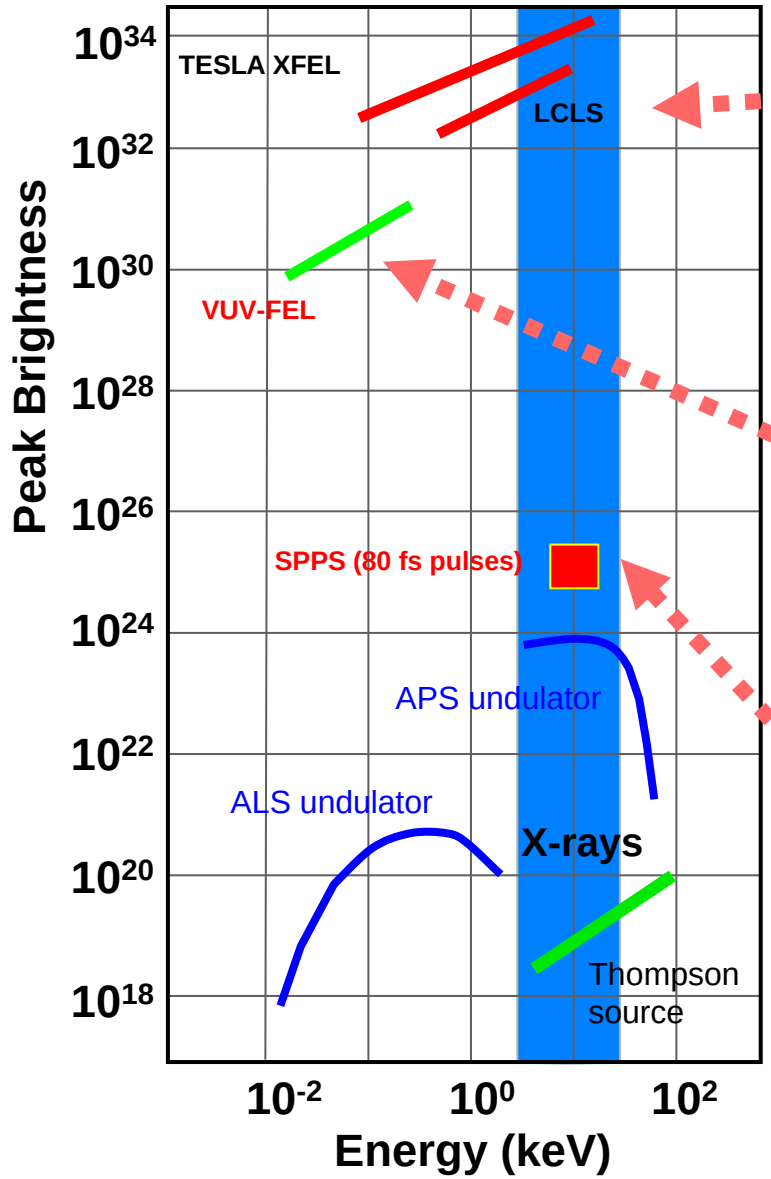
Instrumentation in Progress

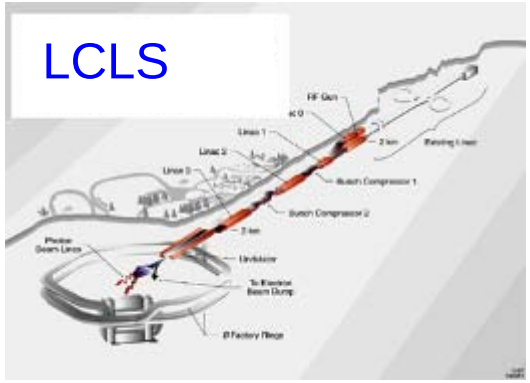

Backscattering Spectrometer – BL 2
Dynamics of macromolecules, constrained molecular systems, polymers, biology, chemistry, materials science
Disordered Materials Diffractometer – BL 1b
Liquids, glasses, polymers and biological macromolecular systems, partially ordered complex materials
Wide-Angle Chopper Spectrometer (ARCS) – BL 18
Atomic-level dynamics in materials science, chemistry, condensed matter sciences
High-Resolution Chopper Spectrometer (SEQUOIA) – BL 17
Dynamics of complex fluids, quantum fluids, magnetism, condensed matter, materials science
High-Pressure Diffractometer – BL 3
Materials science, geology, earth and environmental sciences
BL 1a – Empty
Vibrational Spectrometer (VISION) – BL 16b
Vibrational dynamics in molecular systems, chemistry
BL 16a – Empty
Neutron Spin Echo – BL 15
High-resolution dynamics of slow processes, polymers, and biological macromolecules
Hybrid Spectrometer (HYSPEC) – BL 14B
Atomic-level dynamics in single crystals, magnetism, condensed matter sciences
BL 14a – Empty
Magnetism Reflectometer – BL 4a
Chemistry, magnetism of layered systems and interfaces
Liquids Reflectometer – BL 4b
Interfaces in complex fluids, polymers, chemistry
Cold Neutron Chopper Spectrometer – BL 5
Condensed matter physics, materials science, chemistry, biology, environmental science
Small-Angle Neutron Scattering Diffractometer – BL 6
Life science, polymer and colloidal systems, materials science, earth and environmental sciences
BL 10 – Empty
Macromolecular Diffractometer – BL 11b
Fundamental Physics Beam Line – BL 13
Fundamental properties of neutrons
BL 9 – Empty
BL 8b – Empty
BL 8a – Empty
Powder Diffractometer (POWGEN) – BL 11a
Atomic-level structures in magnetism, chemistry, materials sciences
Single-Crystal Diffractometer – BL 12
Atomic-level structures in chemistry, biology, earth science, materials science, condensed matter physics
Engineering Diffractometer (VULCAN) – BL 7
Engineering, materials science, materials processing

LCLS at SLAC – The World's First X-ray FEL



X-ray Science at SLAC





operational 2010

8 keV, ~100 fs, 10^{12} photons/pulse

Linac Coherent Light Source, SLAC, Stanford

operational now

40 eV, ~30 fs, 10^{13} photons
(500 eV in 2007)

DESY, Hamburg

Rendering of NSLS - II

NSLS-II is a highly optimized x-ray synchrotron project delivering: extremely high brightness and flux; exceptional beam stability; and a suite of advanced instruments, optics, and detectors that capitalize on these special capabilities. About one fourth of the highest brightness beamlines will be instrumented as part of the project.

Challenges

- **We must support the light sources operation that serves the largest number of users in the world. (Three sources are third generation and the NSLS will be replaced by the ultimate storage ring, NSLS II). Budget priorities must be established!**

- **We must find the resources to optimize operation of the most modern neutron source in the world, the Spallation Neutron Source at ORNL. Sustain funding profile!**

- **The LCLS will start users operation in FY 2010 and it will be the only fourth generation x-ray free electron laser in the USA. Operation of the Linac is very costly.**

- **We will continue to enhance our NSRCs capabilities to serve a very large number of users and provide the most advanced set of tools in nano-science. A very cost effective set of facilities with very good industrial and public support.**

- **TEAM, the most powerful electron microscope in the world will start operation in FY 2009 at LBNL. Our electron microscopy centers are very cost effective and serves more than 500 unique users.**

- **We must inform the public of the tremendous impact that the BES facilities have on the scientific and technological advances in the country. Budget priorities need to be established to assure the optimal operation of our best facilities.**