



U.S. DEPARTMENT OF  
**ENERGY**

Office of  
Science

# An Update from the Office of Basic Energy Sciences

**Peter Lee**

**Scientific User Facilities Division  
Basic Energy Sciences  
Office of Science  
U.S. Department of Energy**

**ORNL User Week 2010  
September 13 – 17, 2010 Oak Ridge, TN**

# Outline

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## ***I. Scientific User Facilities***

*Budget*

*Users*

## ***II. Program Update***

- *Strategic Planning*
- *SISGR and EFRCs*
- *LCLS Commissioning*

## ***III. FY 2011 Budget Request***

# FY 2010 BES Budget Appropriation

## Scientific user facilities operations

Increase in operation funding (~ 3%):

- Synchrotron light sources
- Neutron scattering facilities
- Nanoscale Science Research Centers

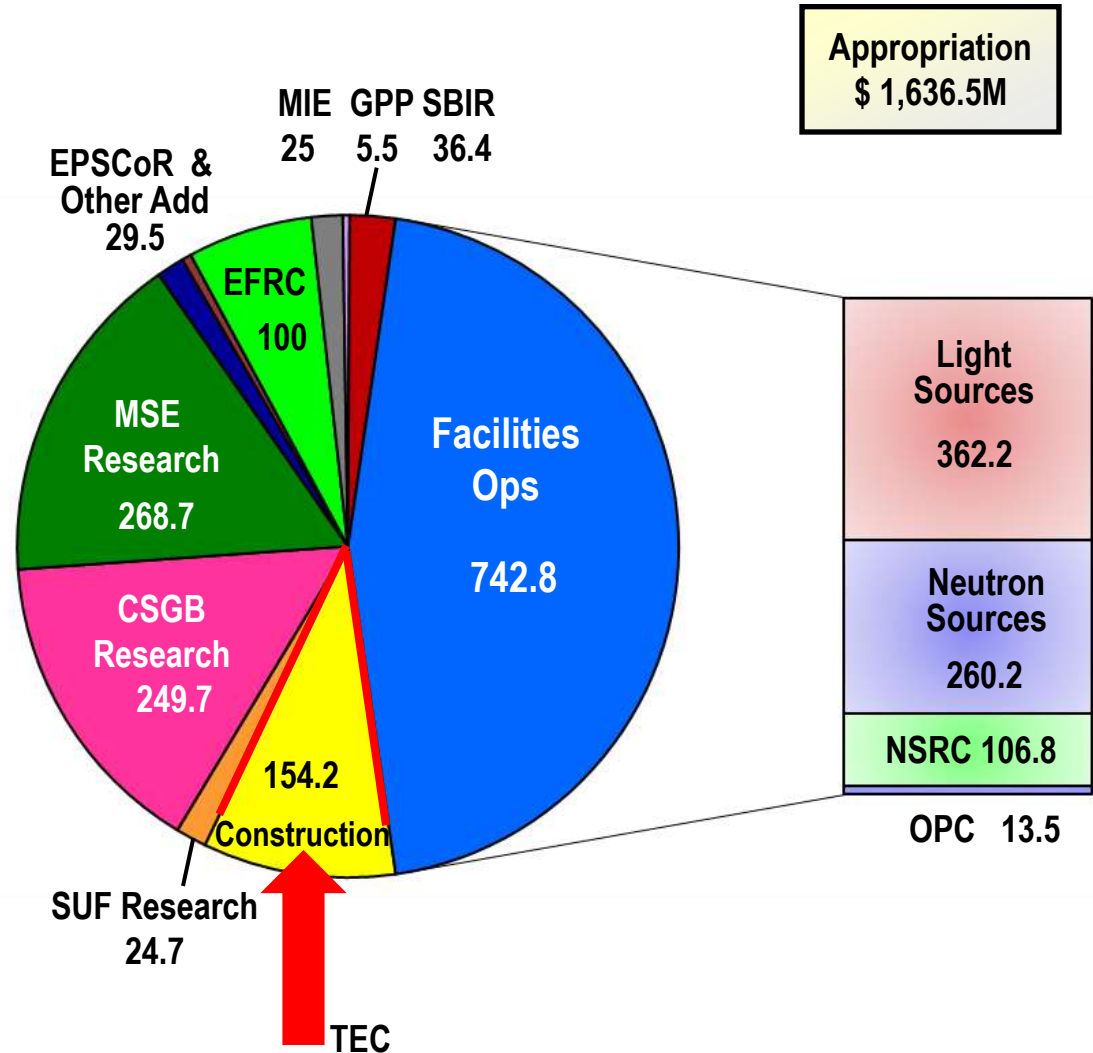
## Construction and instrumentation

Full funding per request for:

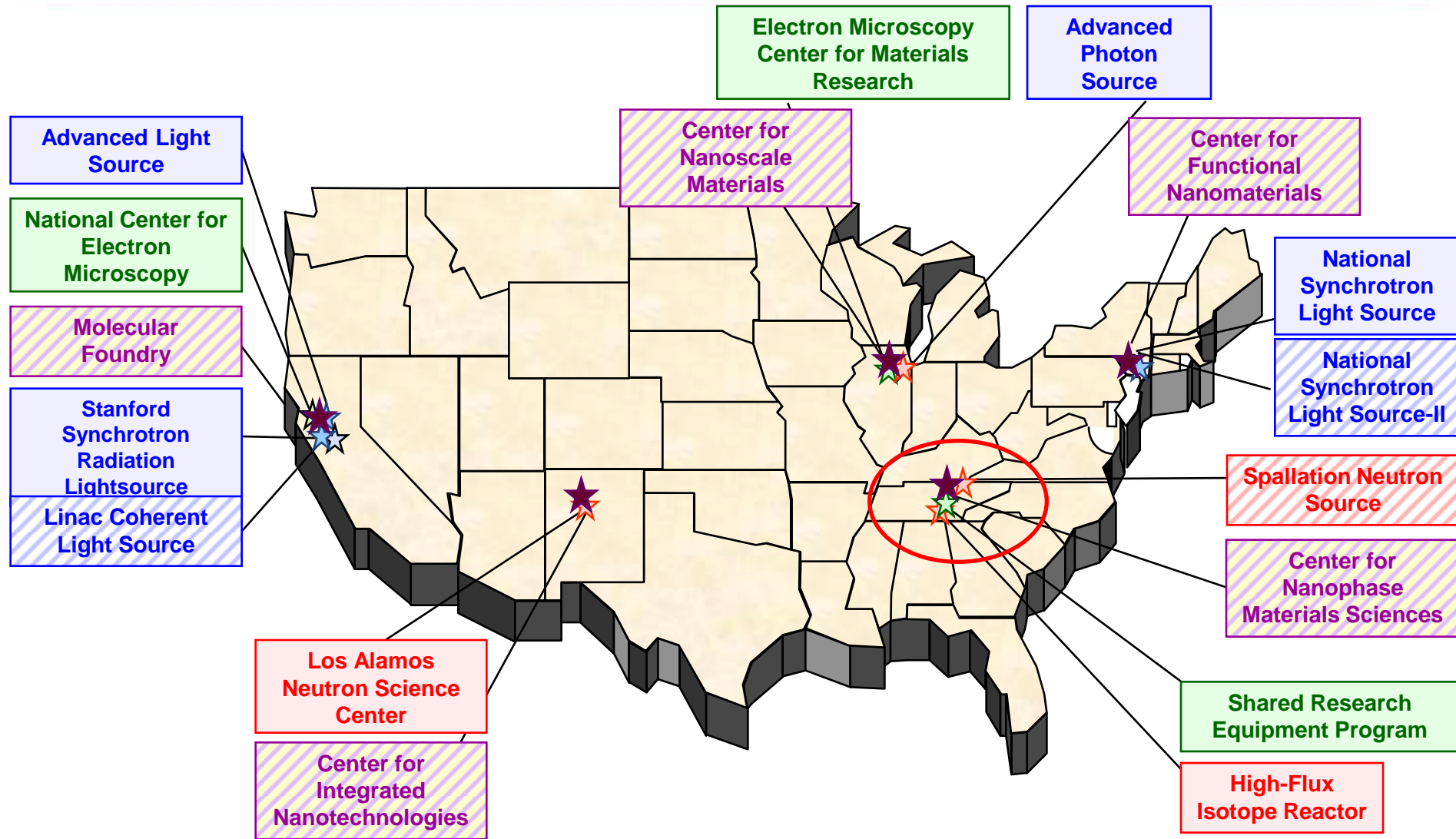
- National Synchrotron Light Source-II
- Linac Coherent Light Source
- Spallation Neutron Source instruments
- SNS Power Upgrade

## Recent Construction TPC Budgets:

- FY07 - \$180.5M
- FY08 - \$159.9M
- FY09 - \$404.8M (Includes ARRA Funding)
- FY10 - \$167.7M



# BES Scientific User Facilities



# Scientific User Facilities Division

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## Light sources

*Stanford Synchrotron Radiation Lightsource SPEAR3 (SLAC)*

*National Synchrotron Light Source (BNL)*

*Advanced Light Source (LBNL)*

*Advanced Photon Source (ANL)*

*Linac Coherent Light Source (SLAC) (operational June 2010)*

## 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/A & 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**



**SSRL**



**Linac Coherent Light Source**



**Manuel Lujan Jr. Neutron Scattering Center**



**High-Flux Isotope Reactor**



**Spallation Neutron Source**



# Five Operational NSRCs



**Center for Functional Nanomaterials  
(Brookhaven National Laboratory)**



**Molecular Foundry  
(Lawrence Berkeley National Laboratory)**



**Center for Nanoscale Materials  
(Argonne National Laboratory)**



**Center for Nanophase Materials Sciences  
(Oak Ridge National Laboratory)**



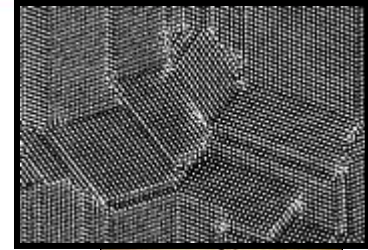
**Center for Integrated  
Nanotechnologies (Sandia & Los  
Alamos National Labs)**



# ***Electron scattering user facilities***



**National Center for Electron Microscopy (NCEM) at Lawrence Berkeley National Laboratory: atomic resolution imaging**



**Electron Microscopy Center (EMC) at Argonne National Laboratory: in-situ studies, including irradiation effects**



**Sub-Angstrom Microscopy and Microanalysis building, under construction**



**Shared Research Equipment (SHaRE) Program at Oak Ridge National Laboratory: microanalysis and spectroscopy**





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## **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.**

# Basic Energy Sciences User Facilities Hosted 11,974 Users in FY 2009

<u>FY 2000</u>	<u>FY 2001</u>	<u>FY 2002</u>	<u>FY 2003</u>	<u>FY 2004</u>	<u>FY 2005</u>	<u>FY 2006</u>	<u>FY 2007</u>	<u>FY 2008</u>	<u>FY 2009</u>	<u>Basic Energy Sciences User Facility</u>
<b>Synchrotron Radiation Light Sources</b>										
2,551	2,523	2,413	2,206	2,299	2,256	2,105	2,219	2,128	2,214	National Synchrotron Light Source (NSLS)
895	907	1,023	867	741	1,007	1,124	1,151	1,147	1,361	Synchrotron Radiation Laboratory (SSRL)
1,036	1,163	1,385	1,662	1,898	2,003	2,158	1,748	1,938	1,918	Advanced Light Source (ALS)
1,527	1,989	2,299	2,767	2,773	3,215	3,274	3,420	3,279	3,537	Advanced Photon Source (APS)
<b>6,009</b>	<b>6,582</b>	<b>7,120</b>	<b>7,502</b>	<b>7,711</b>	<b>8,481</b>	<b>8,661</b>	<b>8,538</b>	<b>8,492</b>	<b>9,030</b>	
<b>High-Flux Neutron Sources</b>										
-	-	-	-	-	-	-	24	165	307	Spallation Neutron Source (SNS)
153	-	22	51	48	96	42	72	258	358	High Flux Isotope Reactor (HFIR)
230	240	243	229	279	244	211	173	89	-	Intense Pulsed Neutron Source (IPNS)
25	122	164	269	339	221	297	272	261	416	Manuel Lujan Jr. Neutron Scattering Center
<b>408</b>	<b>362</b>	<b>429</b>	<b>549</b>	<b>666</b>	<b>561</b>	<b>550</b>	<b>541</b>	<b>773</b>	<b>1,081</b>	
<b>Electron Beam Microcharacterization Centers</b>										
83	88	103	95	128	154	140	199	153	155	Electron Microscopy Center for Materials
201	212	232	253	241	232	205	183	152	149	National Center for Electron Microscopy
99	97	111	112	109	150	132	159	144	161	Shared Research Equipment Program
<b>383</b>	<b>397</b>	<b>446</b>	<b>460</b>	<b>478</b>	<b>536</b>	<b>477</b>	<b>541</b>	<b>449</b>	<b>465</b>	
<b>Nanoscale Science Research Centers</b>										
-	-	-	-	-	-	139	309	404	317	Center for Nanophase Materials Sciences
-	-	-	-	-	-	-	164	303	209	Molecular Foundry
-	-	-	-	-	-	-	189	272	354	Center for Integrated Nanotechnologies
-	-	-	-	-	-	-	112	196	305	Center for Nanoscale Materials
-	-	-	-	-	-	-	-	106	213	Center for Functional Nanomaterials
						<b>139</b>	<b>774</b>	<b>1,281</b>	<b>1,398</b>	
<b>6,800</b>	<b>7,341</b>	<b>7,995</b>	<b>8,511</b>	<b>8,855</b>	<b>9,578</b>	<b>9,688</b>	<b>9,620</b>	<b>10,995</b>	<b>11,974</b>	<b>TOTALS</b>

# BESAC & BES Strategic Planning Activities

## Science for Discovery



## Science for National Needs



## National Scientific User Facilities, the 21st century tools of science



Accelerator  
Physics of Future  
Light Sources  
NIM A

# BES Research — Science for Discovery & National Needs

## Three Major Types of Research Thrusts

increasing progression of scientific scope and level of effort

### ■ Core Research

Support single investigator and small group projects to pursue their specific research interests.

- Enable seminal advances in the core disciplines of the basic energy sciences—materials sciences and engineering, chemistry, and aspects of geosciences and biosciences. Accelerator and detector R&D is also supported.
- Build research programs that provide world-class, peer-reviewed research results cognizant of both DOE mission needs and new scientific opportunities. Scientific discoveries at the frontiers of these disciplines establish the knowledge foundation to spur future innovations and inventions.

### ■ Energy Frontier Research Centers

\$2-5 million-per-year research centers, established in 2009, focused on fundamental research related to energy

- Multi-investigator and multi-disciplinary centers to harness the most basic and advanced discovery research in a concerted effort to accelerate the scientific breakthroughs needed to create advanced energy technologies. Bring together critical masses of researchers to conduct fundamental energy research in a new era of grand challenge science and use-inspired energy research.
- EFRCs are overseen by program staff, who are managed centrally within BES to ensure a unified management strategy and structure.

### ■ Energy Innovation Hubs

\$20 million+ -per-year research centers will focus on integrating basic & applied research with technology development to enable transformational energy applications

- Hubs comprise a larger set of investigators spanning science, engineering, and other disciplines focused on a single critical national need identified by the Department; each Hub is expected to become a world leading R&D center in its topical area to develop a complete energy system.
- With robust links to industry, the highly integrated Hubs can bridge the gap between basic scientific breakthroughs and industrial commercialization.

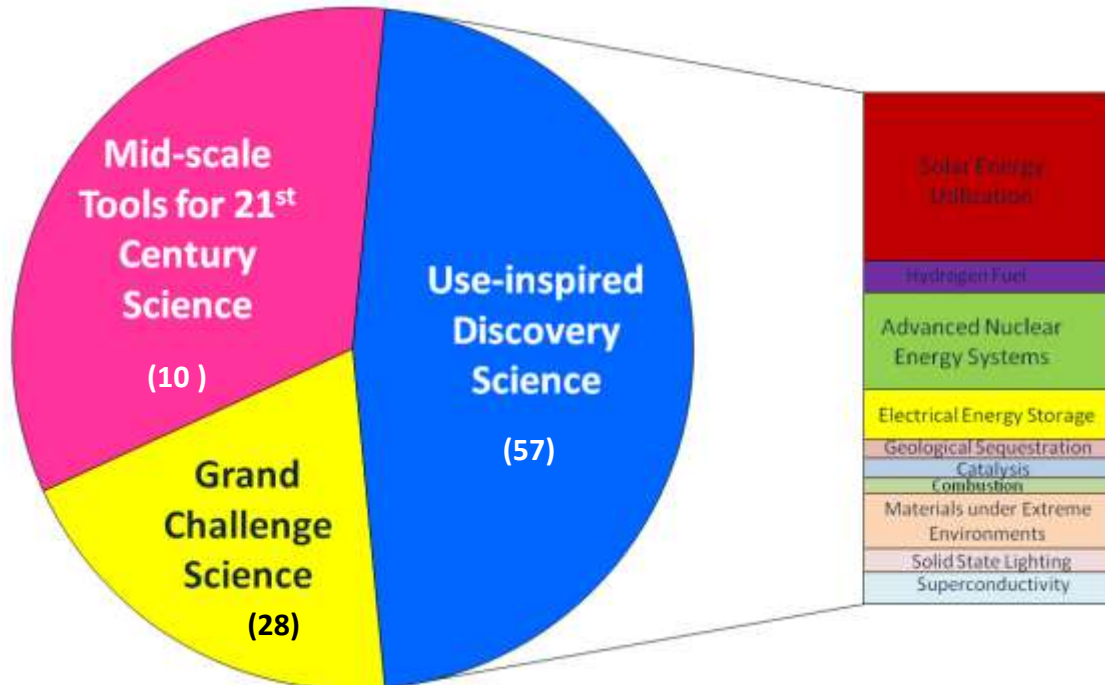
# Single-Investigator & Small-Group Research

**Grand challenge science:** ultrafast science; chemical imaging, complex & emergent behavior

**Use inspired discovery science:** research areas identified in BESAC and BES workshop reports

**Tools for 21<sup>st</sup> century science:** midscale instrumentation

**A total of \$55M was awarded in FY 2009: single investigator awards (\$150 – 300K/yr), small group awards (\$500 – 1500K/vr) for up to three years, and mid-scale instrument (up to \$2M).**



**95 projects were awarded:**

- 72 university awards
- 23 lab awards

**Grand challenge science: 22%**  
**Use-inspired discovery science: 47%**  
**Mid-scale tools: 33%**

**Additional accelerator and detector R&D awards.**

# Energy Frontier Research Centers

*Tackling Our Energy Challenges in a New Era of Science*

EFRC awards provide the recipients with \$2-5 million/year over a five-year award period to pursue collaborative basic research that addresses both energy challenges and science grand challenges in areas including:

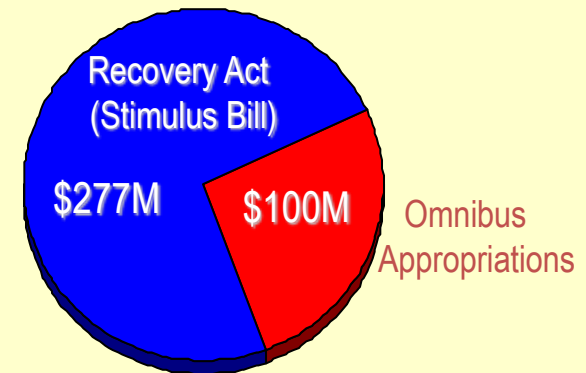
- Solar Energy Utilization
- Bio-Fuels
- Catalysis
- Energy Storage
- Geosciences for Waste and CO<sub>2</sub> Storage
- Advanced Nuclear Energy Systems
- Materials Under Extreme Environments
- Hydrogen
- Combustion
- Superconductivity
- Solid State Lighting

As stated in the Funding Opportunity Announcement for the EFRCs:

“... the research proposed in the EFRC application must:

- 1) address one or more of the challenges described in the BESAC report [Directing Matter and Energy: Five Challenges for Science and the Imagination](#) ([http://www.sc.doe.gov/bes/reports/files/GC\\_rpt.pdf](http://www.sc.doe.gov/bes/reports/files/GC_rpt.pdf)) and
- 2) address one or more of the energy challenges described in the 10 BES workshop reports in the [Basic Research Needs](#) series (<http://www.sc.doe.gov/bes/reports/list.html>).

FY 2009 EFRCs Funding:



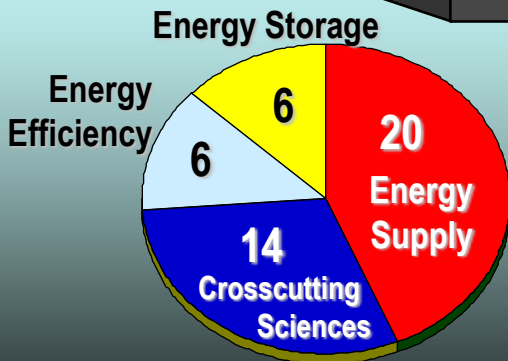
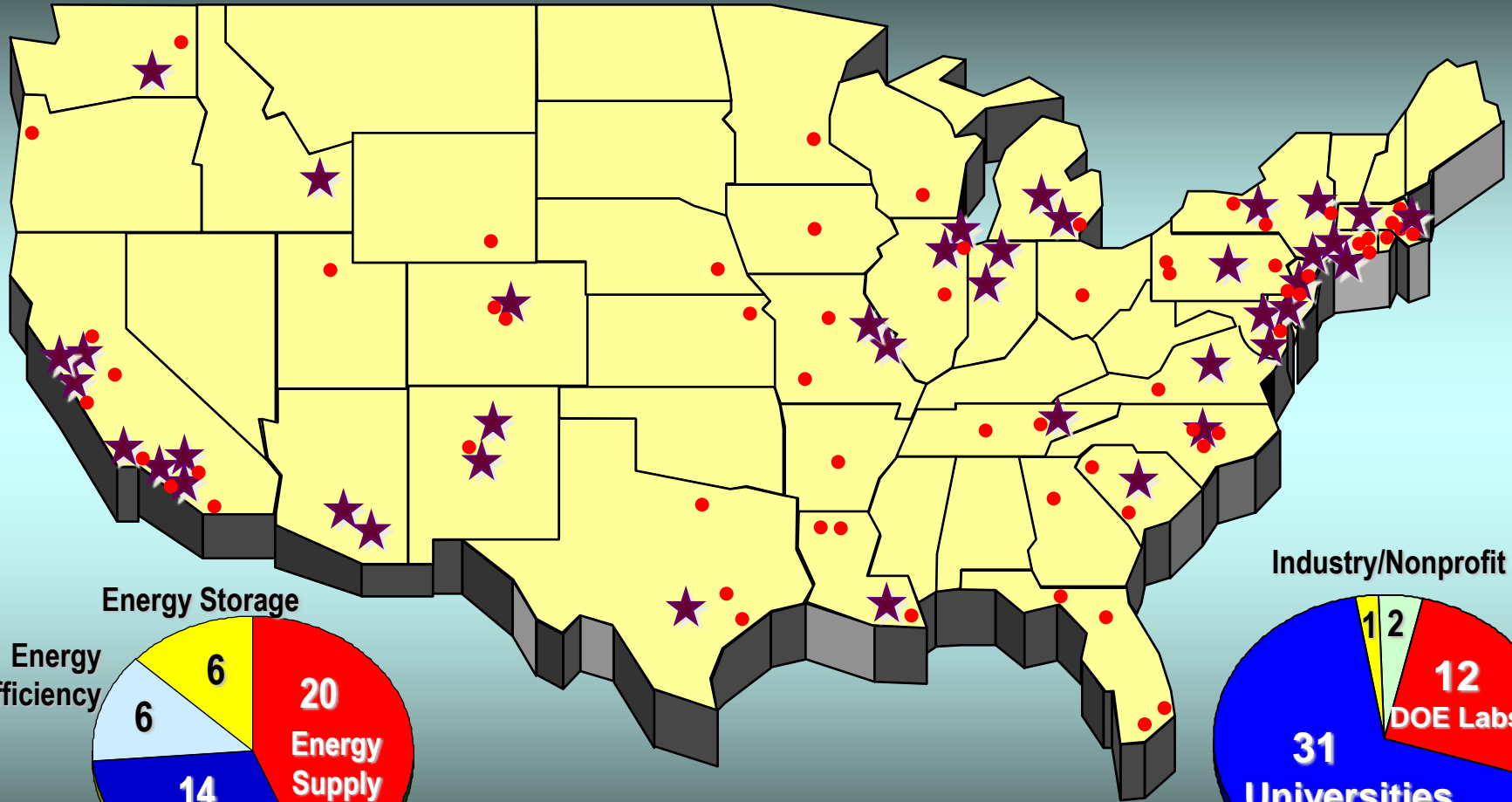
*Total EFRCs = \$777M over 5 years*

# SC/BES Energy Frontier Research Centers

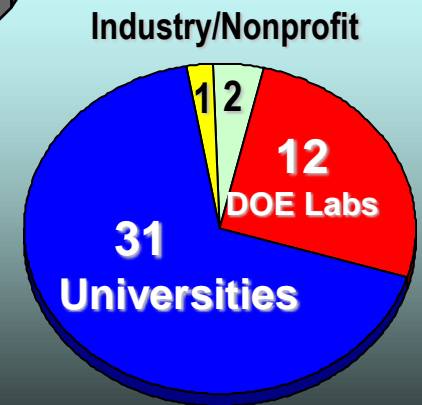
46 EFRCs were launched in late FY 2009 using FY 2009 Appropriations and Recovery Act Funds

46 centers awarded, representing 103 participating institutions in 36 states plus D.C

Energy Frontier Research Center Locations (★ Leads; ● Participants)

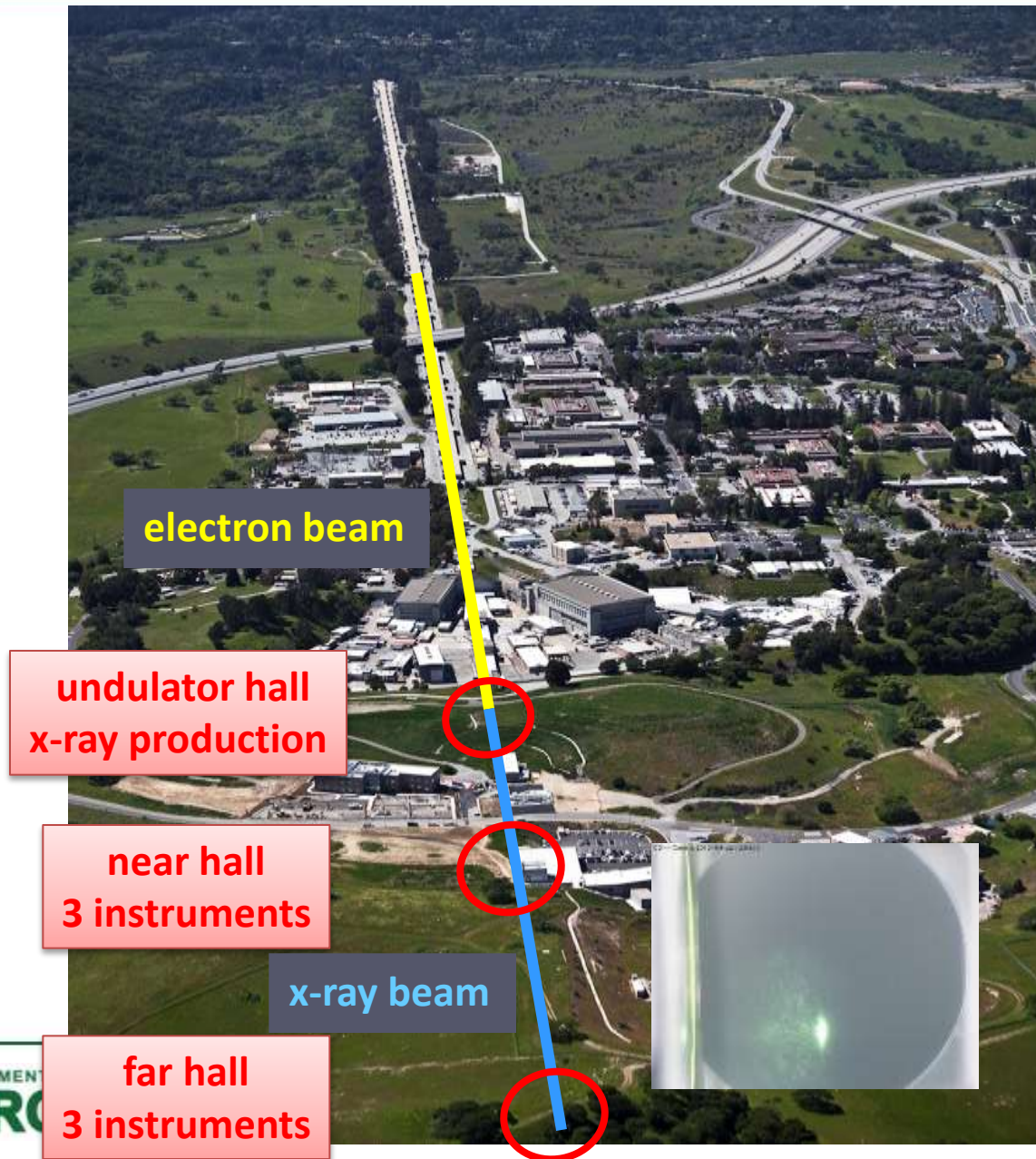


By Topical Category



By Lead Institution

# Linac Coherent Light Source or "LCLS" at SLAC the world's first x-ray laser

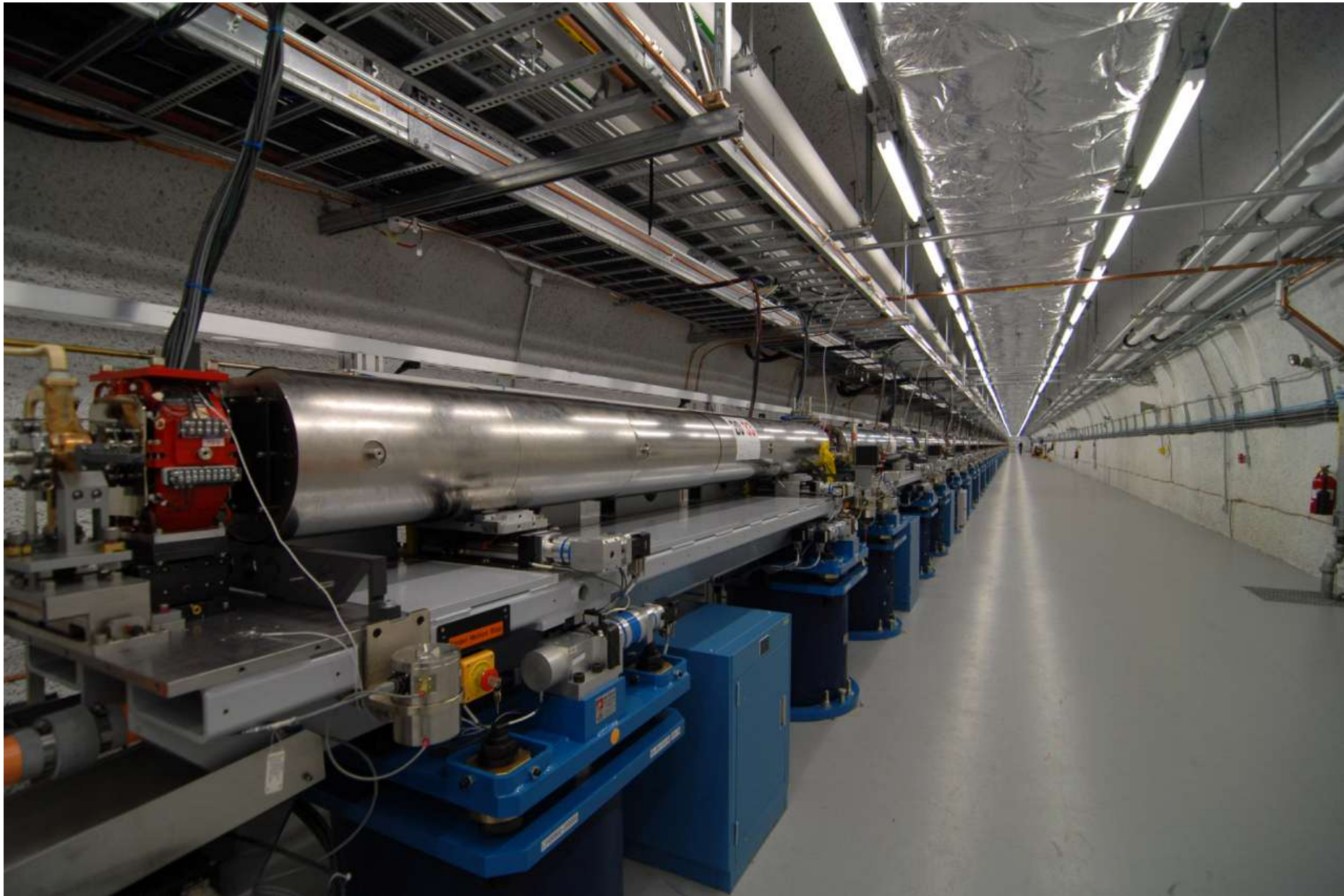


LCLS uses only  
1/3 of linac

Detection  
of X-ray at  
Far Hall ~  
1 PM PDT  
4/22/2010



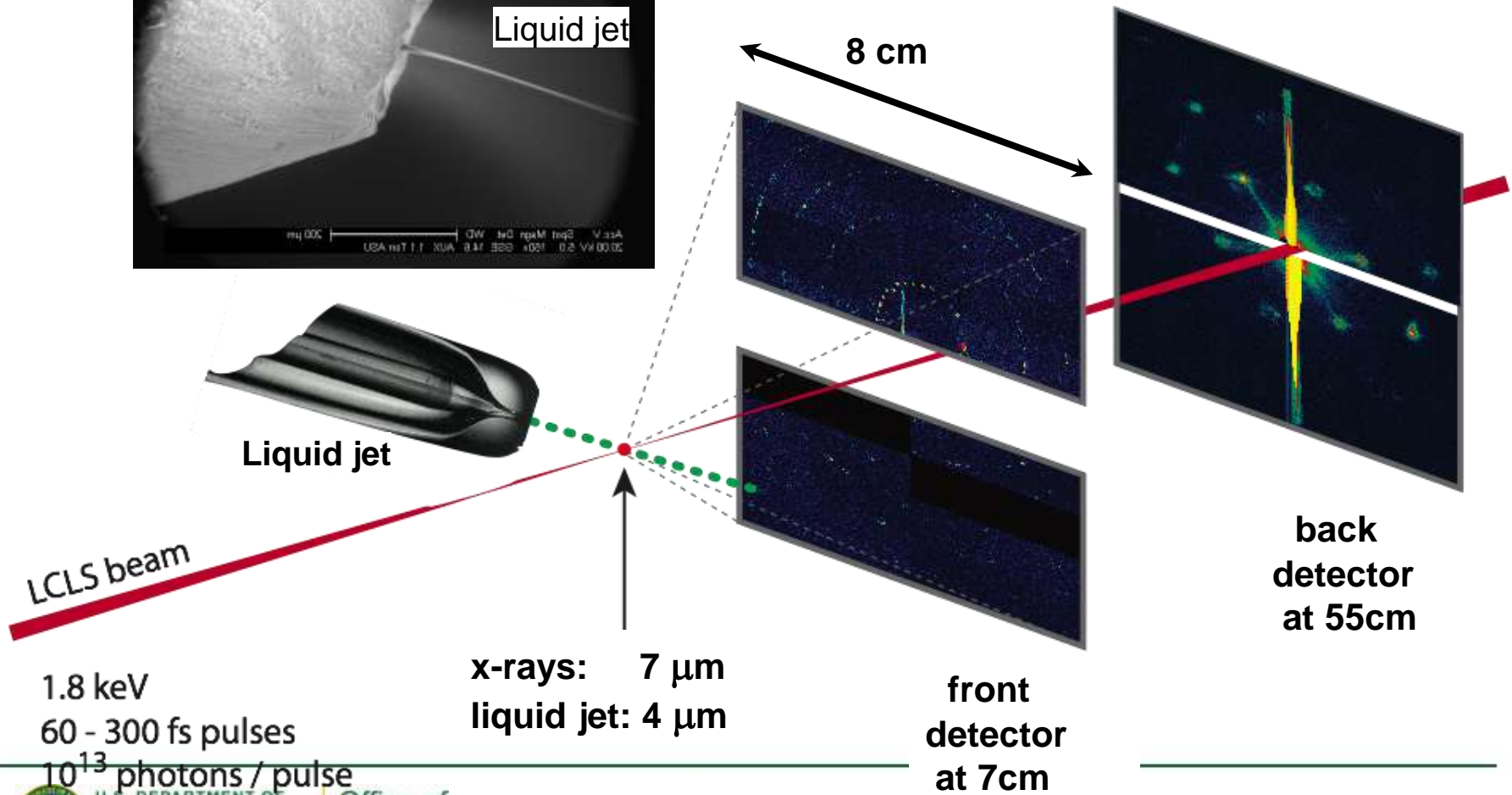
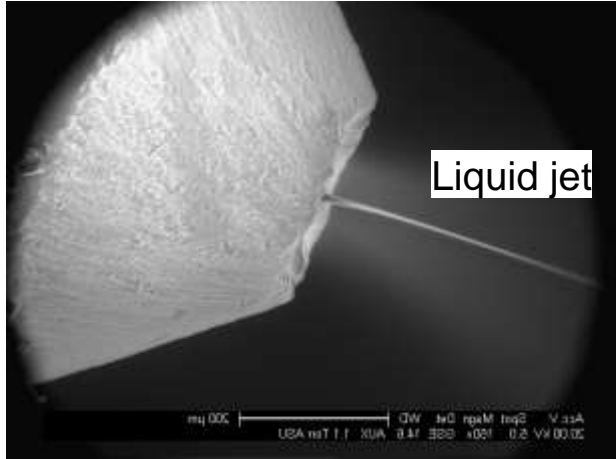
# 132 meters of FEL undulators



# Early studies at LCLS: Nanocrystals in water microjet

Spokesperson: **Henry Chapman** et al.  
collaboration of  
Center for Free Electron Laser Science DESY  
Arizona State University, Max Planck CFEL  
ASG, SLAC, LLNL, CBST, Uppsala University

**John Spence** et al. ASU



1.8 keV  
60 - 300 fs pulses

x-rays: 7 μm  
liquid jet: 4 μm

front  
detector  
at 7cm

back  
detector  
at 55cm

# First results:

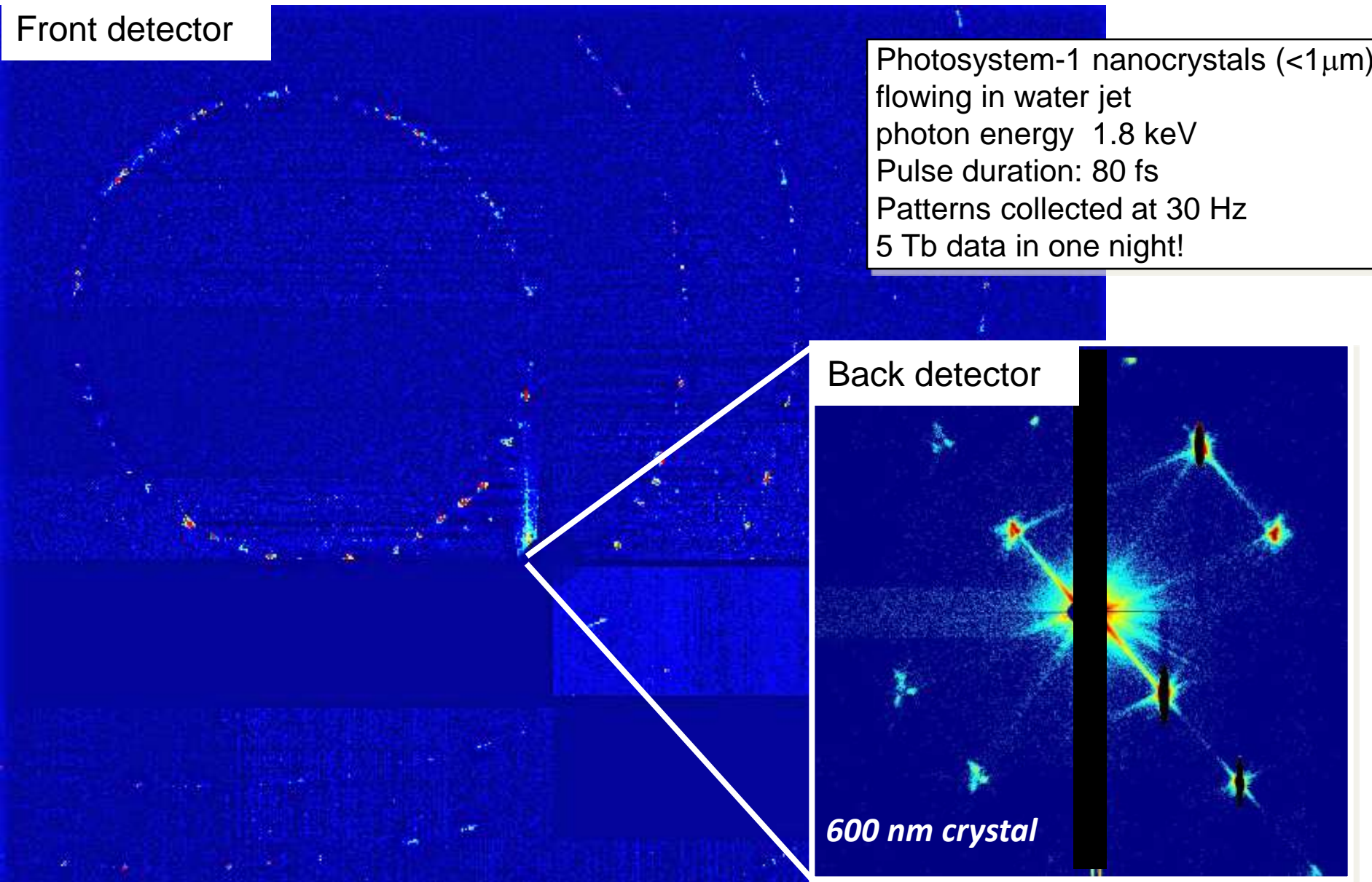
## Single-pulse diffraction from Photosystem-1 nanocrystals

Front detector

Photosystem-1 nanocrystals ( $<1\mu\text{m}$ )  
flowing in water jet  
photon energy 1.8 keV  
Pulse duration: 80 fs  
Patterns collected at 30 Hz  
5 Tb data in one night!

Back detector

*600 nm crystal*



# FY 2011 BES Budget Request

## Research programs

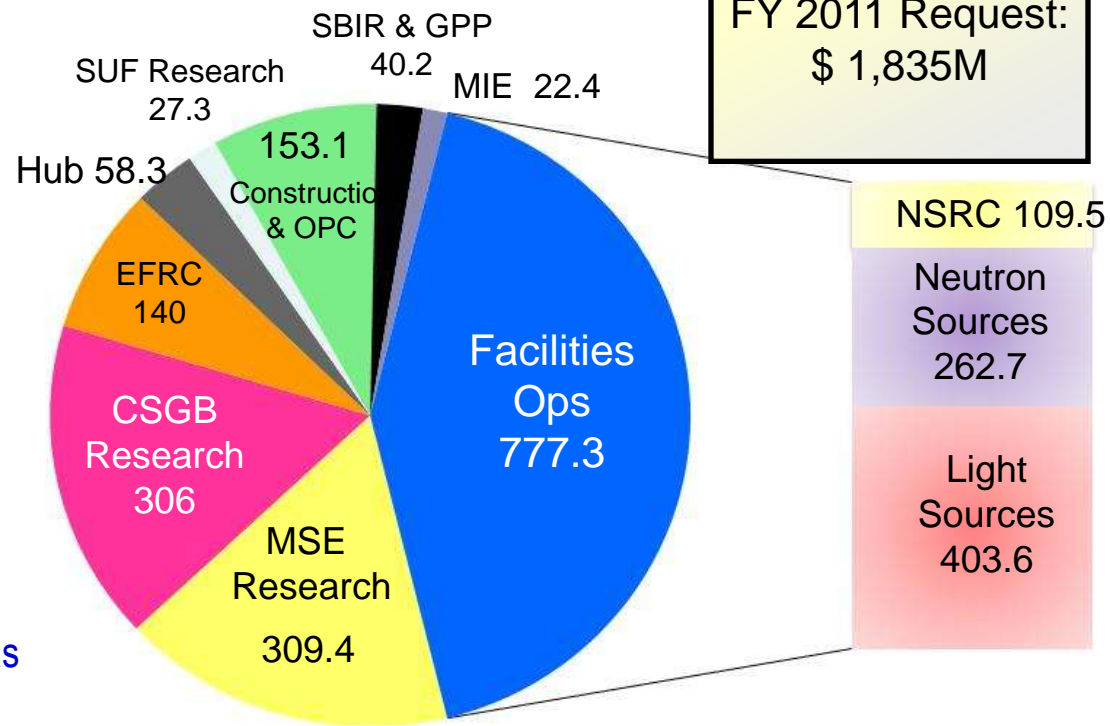
- Energy Innovation Hubs
- Energy Frontier Research Centers
- Core research increases for grand challenge science, use-inspired science, accelerator & detector research
- Topical areas include: basic research in ultrafast science, materials synthesis, carbon capture, radiation resistant materials, separation sciences, advanced combustion modeling for engine design, geophysics and geochemistry on CO<sub>2</sub>/minerals & rocks interactions, and gas hydrates

## Scientific user facilities operations

- Synchrotron light sources
- Neutron scattering facilities
- Nanoscale Science Research Centers

## Construction and instrumentation

- National Synchrotron Light Source-II
- Spallation Neutron Source instruments
- SNS Power Upgrade



# New BES Research Investments Address Critical Needs

*An FY 2011 BES call will cover a broad range of research awards including new EFRCs*

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**About \$66 million will be competed in the BES Program to support additional Energy Frontier Research Centers, single investigators and small group awards in the following areas:**

## **1. Discovery and development of new materials**

The FY 2011 solicitation will emphasize new synthesis capabilities, including bio-inspired approaches, for science-driven materials discovery and synthesis. Research will include crystalline materials, which have broad technology applications and enable the exploration of novel states of matter.

## **2. Research for energy applications**

The FY 2011 solicitation will emphasize fundamental science related to:

- **Carbon capture**, including the rational design of novel materials and separation processes for post-combustion CO<sub>2</sub> capture in existing power plants and catalysis and separation research for novel carbon capture schemes to aid the design of future power plants.
- **Advanced nuclear energy systems** including radiation resistant materials in fission and fusion applications and separation science and heavy element chemistry for fuel cycles.

**Awards will be competitively solicited via Funding Opportunity Announcements following the FY 2011 appropriation.**