

Lawrence Berkeley National Laboratory

The Molecular Foundry

The Molecular Foundry at LBNL

User Program: Science, Experience and Opportunities

David A. Bunzow

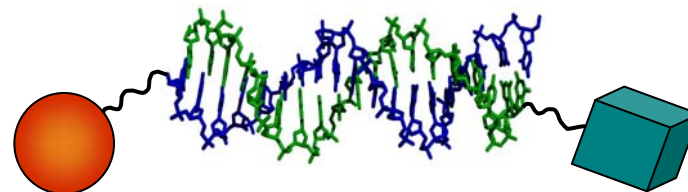
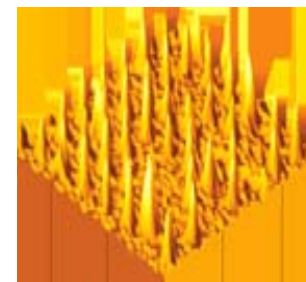
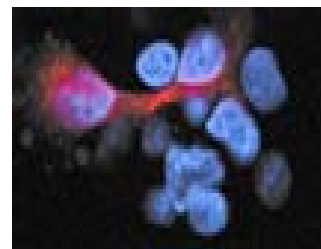
Molecular Foundry User Program Manager

Autumn 2010 EE298-12 Seminar Series

UC-Berkeley September 17, 2010

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OUR MISSION:

THROUGH ACCESS TO STATE-OF-THE-ART INSTRUMENTS, MATERIALS, TECHNICAL EXPERTISE AND TRAINING, THE MOLECULAR FOUNDRY PROVIDES ITS RESEARCHERS WITH THE TOOLS TO ENHANCE THE DEVELOPMENT AND UNDERSTANDING OF THE SYNTHESIS, ANALYSES, CHARACTERIZATION AND BASIC THEORY OF NANOSCALE MATERIALS.



U.S. Department of Energy Nanoscale Science Research Centers

Molecular Foundry

at:
Lawrence Berkeley National
Laboratory
Berkeley, CA

access to:
Advanced Light Source
National Center for Electron
Microscopy
National Energy Research
Scientific Computing Center

Center for Integrated Nanotechnologies

at:
Sandia National Laboratories/
Los Alamos National Laboratory
Albuquerque/Los Alamos, NM

access to:
Los Alamos Neutron Science Center
National High Magnetic Field
Laboratory

Center for Nanoscale Materials

at:
Argonne National Laboratory
Argonne, IL

access to:
Advanced Photon Source
Intense Pulsed Neutron
Source
Electron Microscopy
Center

Center for Functional Nanomaterials

at:
Brookhaven National
Laboratory
Upton, NY

access to:
National Synchrotron
Light Source
Laser Electron Accelerator
Facility

Center for Nanophase Materials Sciences

at:
Oak Ridge National Laboratory
Oak Ridge, TN

access to:
Center for Neutron Scattering
National Center for Computa-
tional Sciences
Shared Research Equipment
Collaborative Research Center



DOE NSRC “Business Model”

Make Basic Nanoscience Discovery Easier To Do

- ***ENCOURAGE CROSS-DISCIPLINARY INVESTIGATIONS LEADING TO CRITICAL SCIENTIFIC DISCOVERIES WITH HIGH IMPACT ON GLOBAL ISSUES***
- ***BASIC ENERGY-RELATED RESEARCH – KEY TO OUR COLLECTIVE FUTURE!***
- ***SCIENCE FOR THE PUBLIC GOOD – DRIVES OUR OPERATIONS & THEMES***
- ***ATTRACT & ENCOURAGE MORE NON-PROPRIETARY INDUSTRIAL USERS***
- ***ENCOURAGE MORE NON-UC USER PROPOSALS AND COLLABORATIONS***
- ***SHORTEN THE RESEARCH-DEVELOPMENT-VC-STARTUP-MANUFACTURING PROCESS CONTINUUM***



LEED Gold Status - USGBC

The Molecular Foundry (TMF) Design

- ***Building initial design in 2003-2004 (Architects = Smith Group)***
 - 6 floors of high tech science labs and clean rooms
 - seismically stabilized (Hayward Fault < 0.5 miles away)
 - main entrance on 5th floor – at street level!
 - integrated systems used to control HVAC, water and electricity
- ***Completed and occupancy in early 2006***
 - 96K sq. ft. (additional “jump start” facilities in adjacent locations)
 - \$67M building costs and \$25M in equipment and support (growing!)
 - meets CA Title 24 green building design standards (toughest in U.S.)
 - annual operating budget = \$18M + ~10% new capital equipment/year
- ***LEED Gold status by US Green Building Council (2007)***
 - 35% less energy consumption than ASHRAE 90-1 standard defines
 - 85% less GHG emissions than ASHRAE 90-1 standard allows
 - 85% of construction waste materials were recycled
 - mechanical and electrical systems designed at 15watts/ft²
 - extensive use of low VOC emission products throughout
 - optimized use of low e-glass, bamboo and natural landscaping

Molecular Foundry Physical Attributes

State of the Art Basic Nanoscience Research Facility

- **6 floors vertical alignment – overlooks UC- Berkeley campus**
 - all facilities, support activities, hazmats and storage located within one building
 - 96,000 sq. ft under one roof (about 40% underground to utilize natural insulation)
 - minimal parking available (by design - to encourage employee use of public transportation)
- **35,000 sq. ft. of basic science labs**
 - some traditional lab spaces
- **5,000 sq. ft clean rooms (primarily ISO Class 4 & 6)**
 - e-beam lithography system in separate enclosure isolated within a clean room (ISO Class 3)
 - video monitoring of activities
- **Decision to pursue LEED silver design based on many assumptions**
 - http://eetd.lbl.gov/EMills/PUBS/PDF/High_Tech_Roadmap.PDF
 - <http://www.labs21century.gov/>
 - <http://eetd.lbl.gov/emills/PUBS/HighTechBusinessCase.html>
 - http://hightech.lbl.gov/documents/DataCenters_Roadmap_Final.pdf
 - <http://eetd.lbl.gov/EA/mills/EMills/PUBS/LabEnergy/LabEnergy.html>

Issues – High Tech LEED Design vs. Operation

Operational Realities can be Cruel

Optimized Designs vs. Operational Realities for High Tech Facilities

- LEED design needed to attain “gold” status not compatible with high tech facilities (2003/04)
- Initial costs assumed specified rates of return for justifying added costs (amortization)
- “Every high tech LEED design is a redesign waiting/begging to happen from moment of use”
- LEED for labs being considered – joint project with PG&E and USGBC in CA

Adverse impacts by humidity control strategies in clean rooms & labs

- huge energy usage penalties based on operating equipment inefficiencies (+1.3% lab-wide!!)

Huge problems/costs associated with building operational pressures

- day time/night time loading differences cause experimental variations with specific equipment
- building pressure differentials cause lab pressure differential interlocks to alarm

LEED design not compatible with nanoparticles and workplace controls with respect to human health needs

- cannot guarantee nanoparticle containment within control zones and enclosures

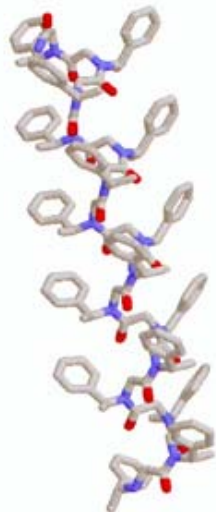
Bottom line: we were “then honored and now humbled” by facility costs projected vs. actual based on LEED Gold awarded to building design

- Consumption = 300,000 kWh/month = 3kWh/month/sq.ft. = 4.5 watts/sq.ft. (~30% of design)
- 2,764,000 gallons/year = ~7572 gallons/day = 58 gallons/day/person (all uses – mostly lab DI)
- still plenty of room for optimization/improvement/redesign/reengineering (ROI is very critical)

Molecular Foundry Research Themes

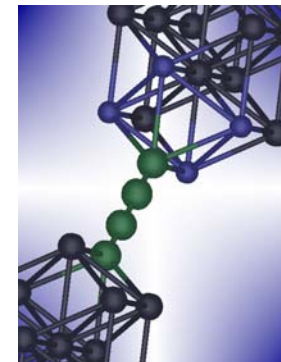
Combinatorial Nanoscience

- Robotic synthesis to generate and test large libraries of biological and inorganic nanostructures utilizing highly automated parallel processing



Nanointerfaces

- Engineering and analyzing properties of hybrid nanomaterials via synthesis of heterostructures and interfaces, and first principle simulations

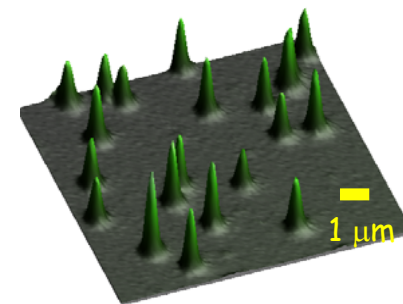
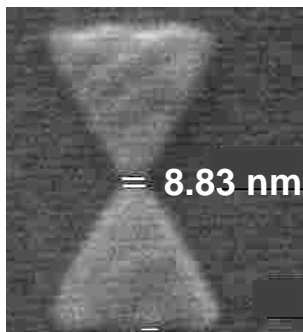


Multimodal in situ Nanoimaging

- Applying multiple imaging techniques towards investigation of dynamic nanoscale phenomena at liquid, vapor and solid interfaces

Single-digit Nanofabrication

- Fabricating nanoscale structures, features and spaces <10 nm on biological, macromolecular and inorganic substrates using probe-based surface modifications and advanced lithography tools.



The Molecular Foundry's Six User Facilities

- ***Imaging and Manipulation of Nanostructures***
 - Characterization, analysis, visualizations and manipulation of nanostructures
- ***Nanofabrication***
 - Advanced e-beam lithographic, nanoimprint, ALD, PECVD, ICP and multiple thin-film deposition and etch processing techniques
- ***Inorganic Nanostructures***
 - Science of semiconductors, spintronics, MOCVD, and carbon and hybrid nanostructures including graphene electronics
- ***Organic and Macromolecular Syntheses***
 - Studies of “soft” materials: organic molecules, macromolecules, polymers and their assemblies
- ***Biological Nanostructures***
 - New bio-materials; new probes for bio-imaging; peptoids, synthetic biology structures and techniques including robotic parallel processing
- ***Theory of Nanostructured Materials***
 - Theoretical support to guide understanding of new principles, behavior and experiments



Molecular Foundry Staff and Assignments

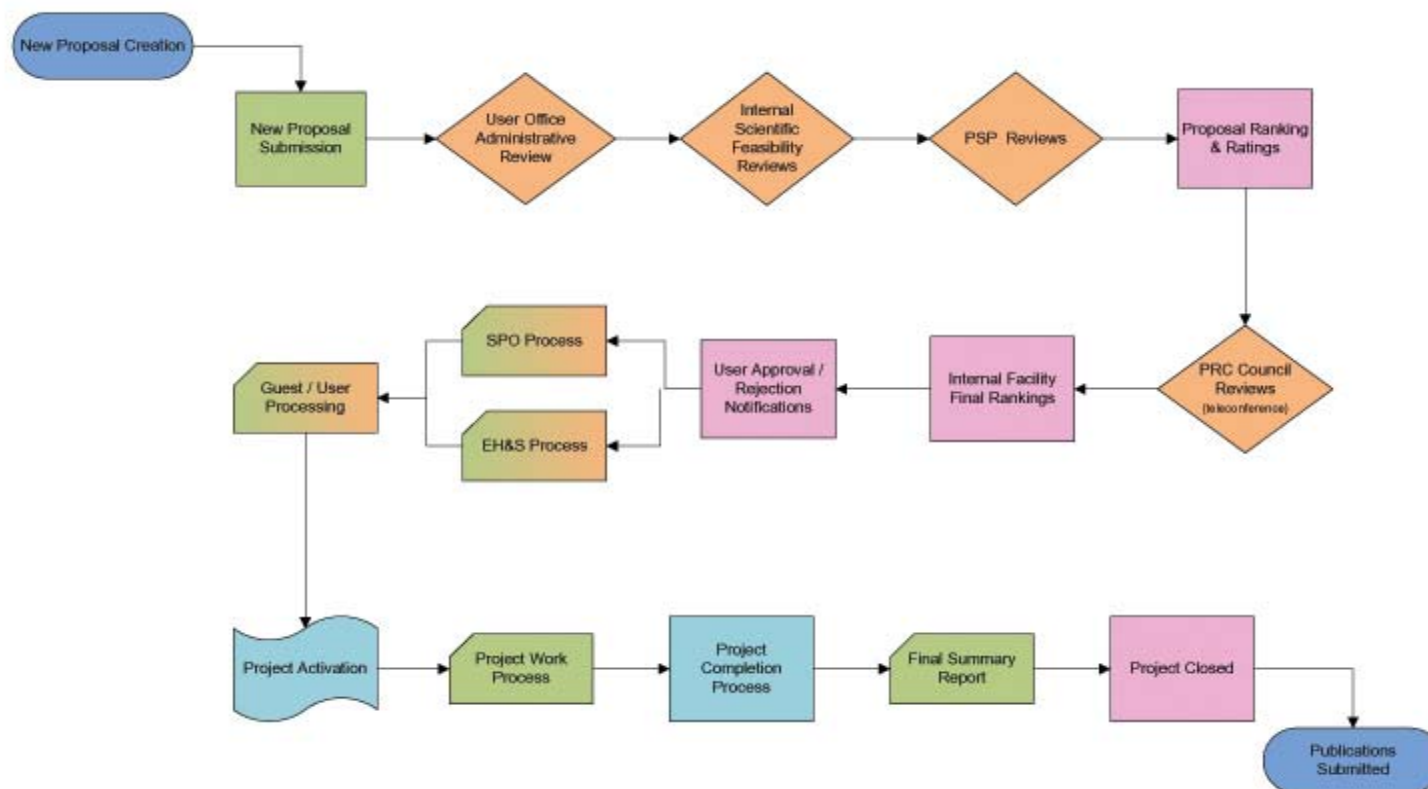
A Distinguished Research & Support Staff

- **Senior Management: 1 Director; 2 Deputy Directors**
- **Facility Directors: 6 (1 each facility – lead operations)**
- **Staff Scientists: 25 PhDs – career path assignments**
- **Staff Scientists are 50% user-dedicated**
- **Technical Support Staff: 10 BS/MS – career positions**
- **Post Docs: 65-70; funded by staff scientists' own grants**
- **College/University Grads/Undergrads: 15 researchers**
- **Administrative Support: 6 people (2 public relations)**
- **User Program Office: 5 people (2 UG student interns)**



BASIC FLOW CHART PROPOSAL DATA BASE

FEBRUARY 24, 2010



The Foundry User Program – Process Overview

- ***Call for Proposal Submissions – >250 proposals input per year!!***
 - 2 formal “Calls” per fiscal year (January, July) for standard proposals
 - Web-based proposal preparation and submission – submit anytime
 - 4 weeks submission window at each Call – 14 week total process time per cycle
 - Standard Proposal; Instrument Only; Sample Only – proprietary & non-proprietary
- ***Feasibility and Core Competencies Assessment (internal)***
 - Capacity and coordination with support facilities (user facilities and affiliated labs)
 - Capabilities of PI and investigators in collaboration with TMF staff
 - EH&S evaluations (utilizes data supplied by PI via proposal submission)
- ***Proposal Review Panels (external) and Applicable Criteria***
 - Leaders in their field; SMEs recruited from external institutions and industries
 - Rotate academic and industrial contributors to gain multiple perspectives
 - Scientific merit and technical feasibility – quantitative scores in 3 categories
 - Expectation of publication in open literature by DOE
- ***Proposal Submission Forms and User guide – program info!!***
 - Create a user account and prepare/submit your proposal
 - <https://isswprod.lbl.gov/TMF/login.aspx>
 - Contact us anytime via e-mail at: foundry@lbl.gov



TMF User Program – Post Acceptance Process

CONGRATULATIONS!

Your Proposal has been Accepted!! WHAT'S NEXT??

- **User agreements required between collaborating entities and LBNL**
 - *Umbrella DOE user agreements good for 5 years (1st time only)*
 - *Each specific project has an “Appendix A” agreement (18 months)*
 - *Proprietary research activities will require a CRADA*
 - *MTAs / UBMTAs may be needed for a Sample-Only proposal*
- **Project start date negotiated**
 - *Depends on Foundry & support facilities capacity and loading*
 - *Assigned by our Lead Facility working with listed support facilities*
 - *Depends on user agreements and EH&S data submission & review*
 - *Projects authorized for 365 days maximum from work start date*
- **Project completion and wrap-up**
 - *Requires final report be submitted*
 - *Notification of publication in journals*
 - *Project continuation possible by mutual agreement*
 - *May require follow-on proposal submission to avoid “scope creep”*



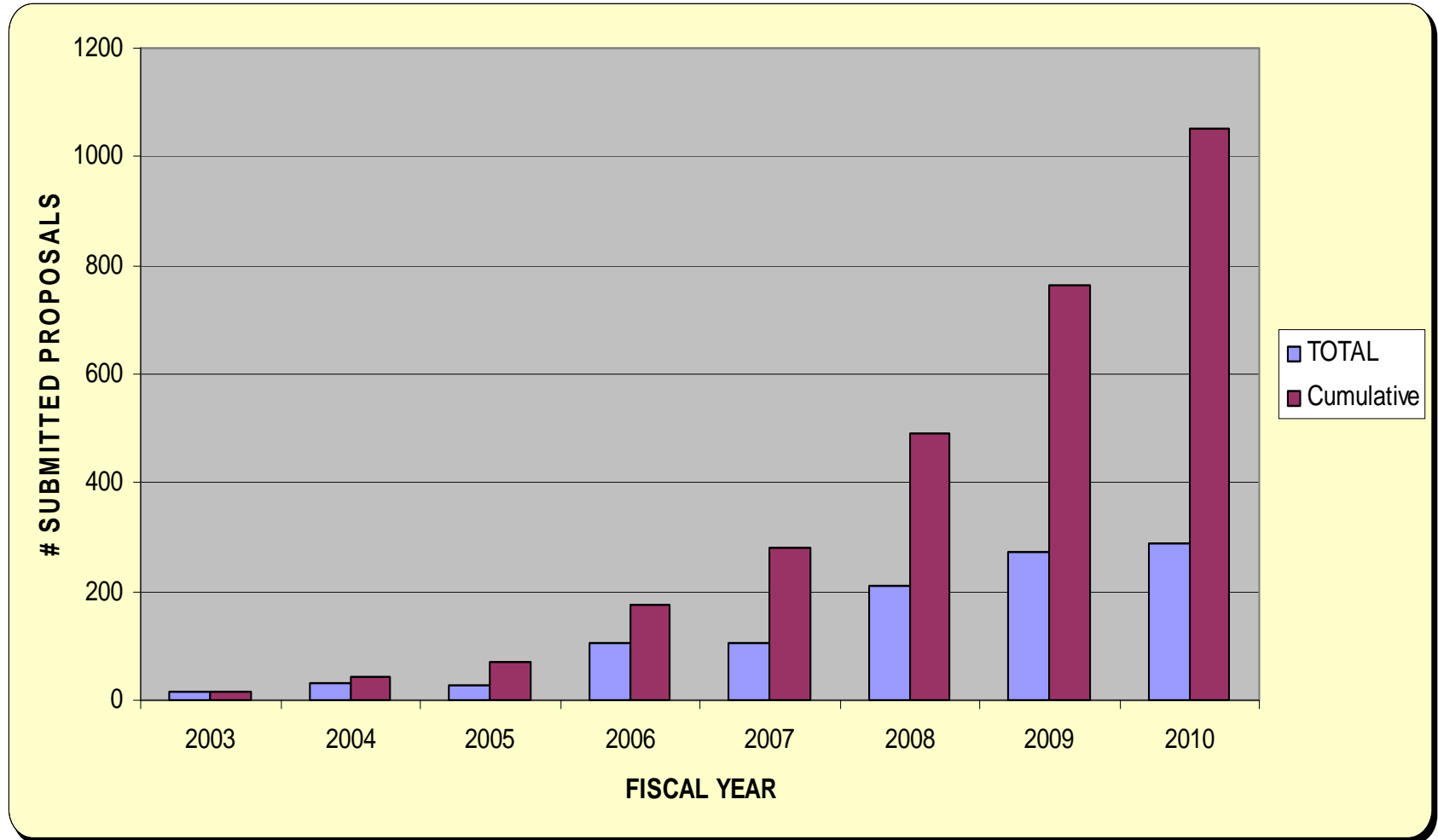
Our Measure of Success at TMF – User Satisfaction

Aggregate Foundry User Statistics (3/2006 - 9/2010)

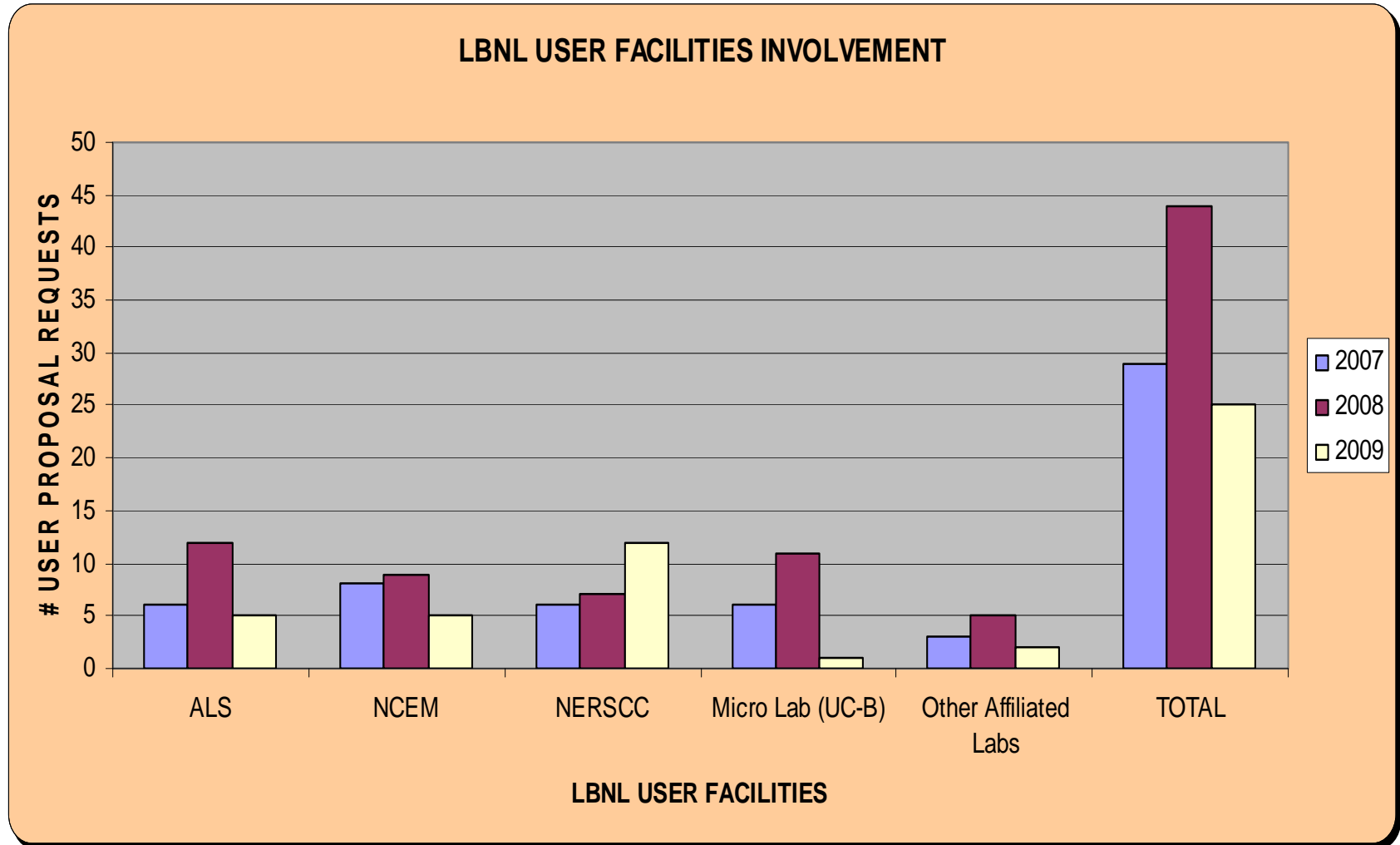
- **1033 proposals received;** *standard; instrument only; sample only*
- **605 proposals approved;** *since 10/2005 – acceptance rate = 59%*
- **357 proposals completed;** *184 active; 64 pending; 92 in review*
- **32 states and 18 countries represented;** *~2.5 users/proposal*
- *~ 11% from industry; increasing in number – very few proprietary*
- *~ 24% from government; mostly other DOE user facilities*
- **1808 users for on-site collaboration @ TMF – thus far!**
- **322 peer reviewed publications;** *161 from users as lead author*
- **New equipment – ALD, ICP, RIE, in situ TEM, nano-Auger, PECVD**
- **DOE thrust – engage industry to shorten commercialization cycles**
- **The future of TMF @ LBNL – energetic, bright and growing!**



Total # of Submitted Proposals is Increasing!

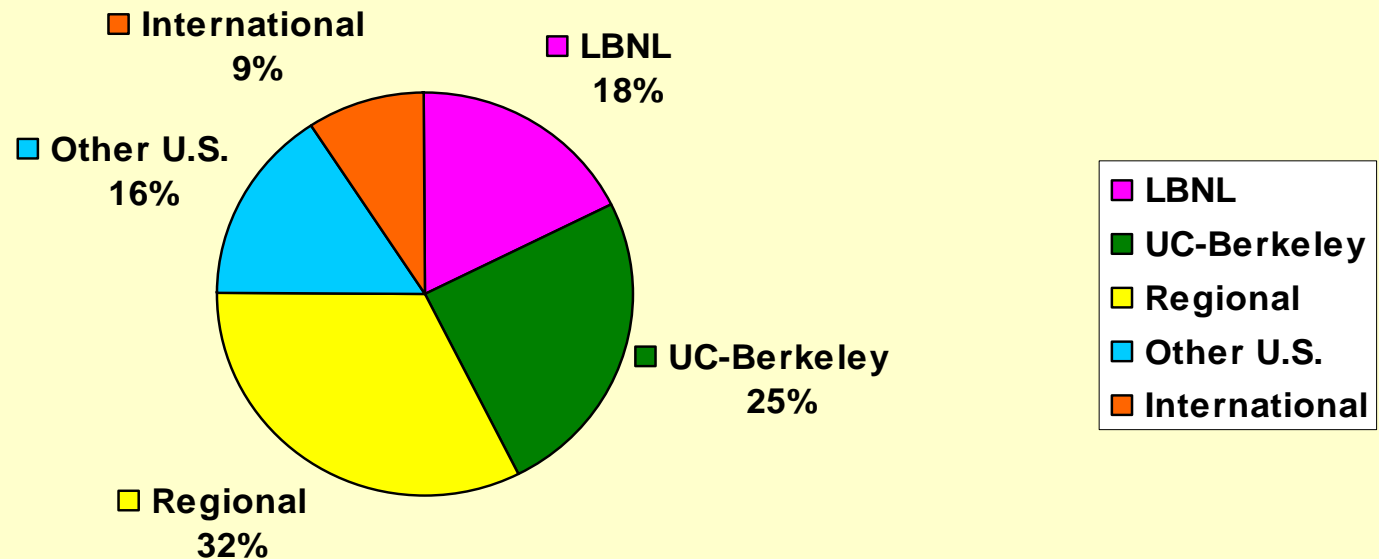


Utilization of Other LBNL User Facilities



Distribution of User Proposals by Origin

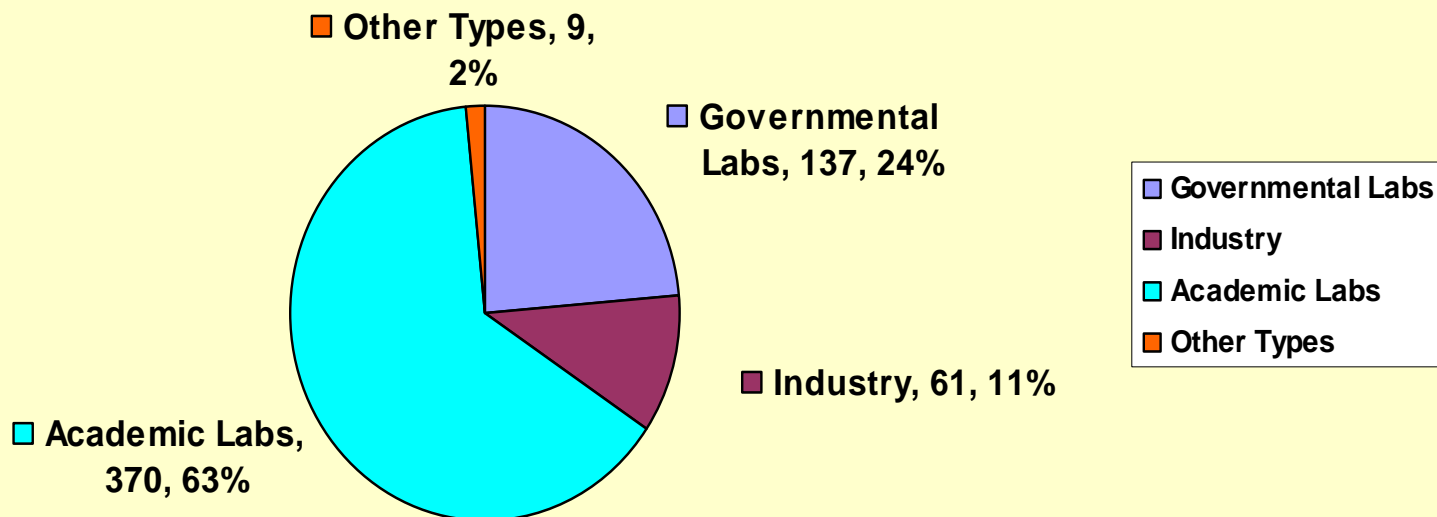
GEOGRAPHICAL ORIGIN ALL SUBMITTED PROPOSALS



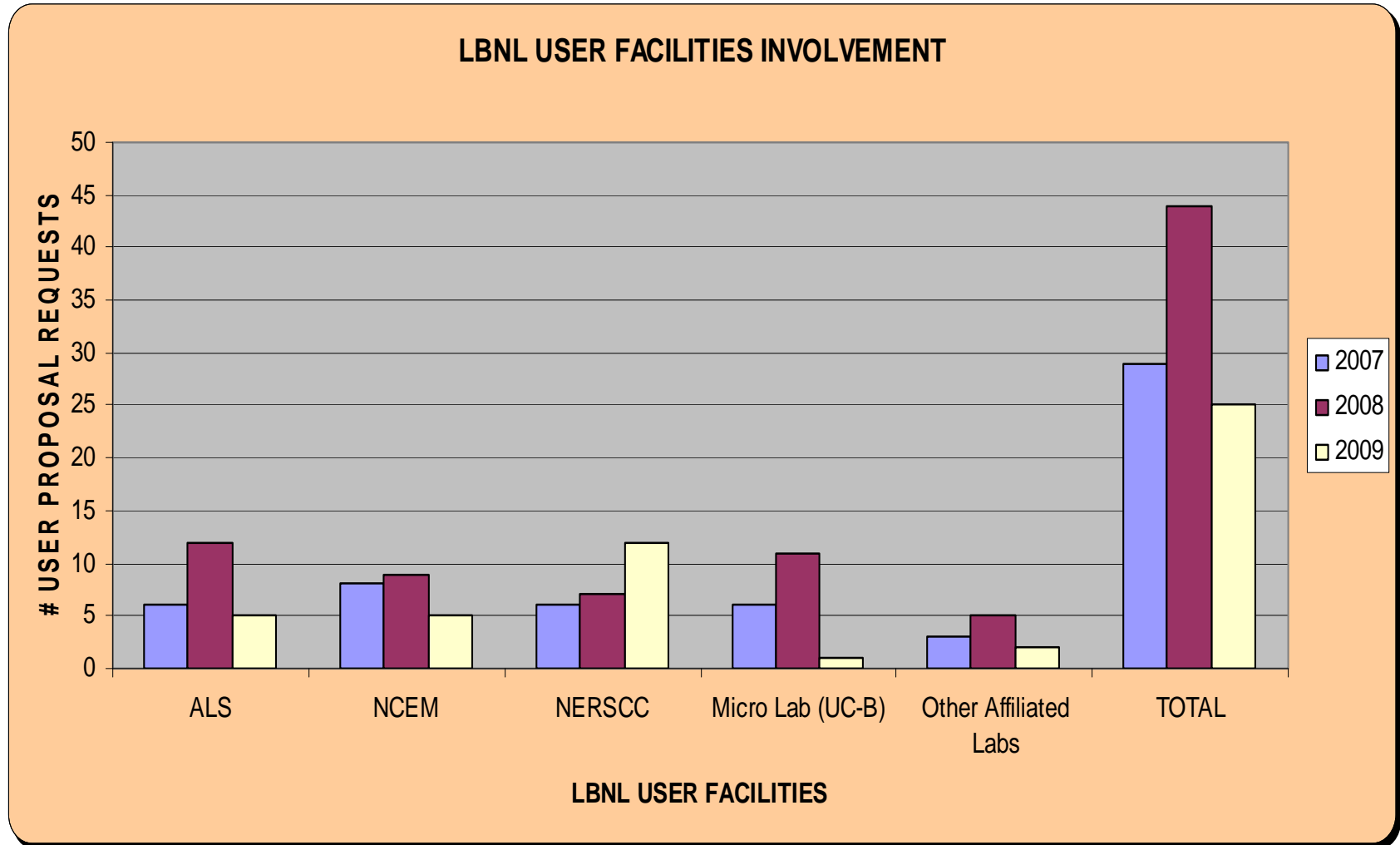
Distribution of Proposals (2007-2009)

Industrial & Government Labs are Catching Up to Academia!

CATEGORIES OF FOUNDRY SUBMITTED PROPOSALS



Utilization of Other LBNL User Facilities



Safety & Health Considerations in Nanotechnology

Some Critical Issues to Contemplate & Overcome

- **Berkeley, Cambridge and Madison** – *political pressures or real issues?*
- **Public perceptions** – *need to be considered and incorporated*
- **Industry standards** – *will become critical (IEST; NIOSH; DOE; NNI, etc.)*
- **R.J. Kelly** “*Occupational medicine implications of engineered nanoscale particulate matter*” *ACS JCHAS (March, 2008)*
- **NIOSH Nanotechnology Safety and Health Recommendations (2009)**
- **Several reports of fatalities attributed to nanoparticles** – **facts?**
- **Public education about nanotechnology** – *will continue to be vital*
- **Bay Area is “at the epicenter of nanorevolution” WWI/PCT (8/2009)**



Nanotoxicity Research Critical to Success

- **Work underway in various research laboratories**
 - ***Universities***
 - ***Industry***
 - ***National Laboratories***
 - ***Government Labs***
- **Several organizations doing parallel work**
 - ***NIOSH***
 - ***ACGIH***
 - ***EPA***
 - ***OSHA***
 - ***Public Health Facilities***
 - ***IEST***
 - ***TC209/229***



The Molecular Foundry (TMF) at LBNL

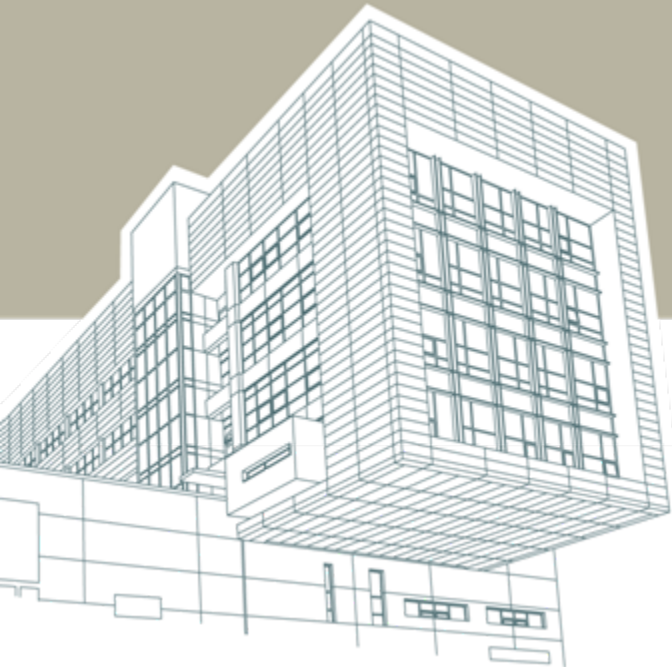
Summing Up...

- *TMF – 1 of 5 DOE NSRCs co-located at 6 national labs*
- *TMF has a history of enabling basic nanosciences research*
- *Our User Program is robust and encourages collaboration and partnerships with industry, government and academia*
- *TMF integrates a strong nanoscale safety and health culture and environmental concerns into all our user projects*
- *TMF user statistics show strong growth potential at multiple interfaces of basic nanoscience research*
- *The Molecular Foundry wants you...! www.foundry.lbl.gov*





Did I fail to mention the otherwise tremendous not-too-shabby view?



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The Molecular Foundry

Next user proposal submit deadline:

January 15, 2011

<http://foundry.lbl.gov/user2010/>

9/30 – 10/1/2010

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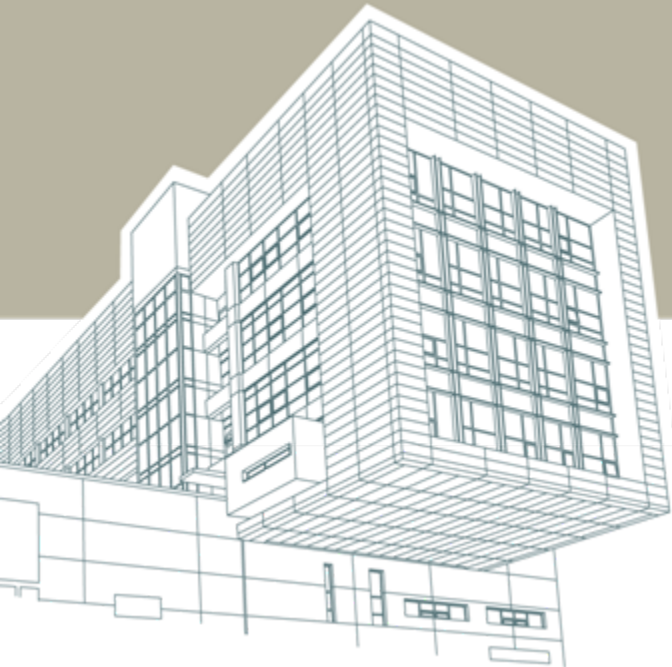
Phone: 510-486-4574

Fax: 510-486-7424

Cell: 701-541-2354

<http://foundry.lbl.gov/>





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The Molecular Foundry

Through access to state-of-the-art instruments, materials, technical expertise and training, the Molecular Foundry provides researchers with the tools to enhance development and promote understanding of the synthesis, characterization and theory of nanoscale materials.

ACKNOWLEDGEMENT

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