Synergy Between NSRCs and Co-located Facilities/Inter-NSRC Collaboration

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The NSRCs strategic scientific directions

Each NSRC has a strategic focus that defines science strengths

CFN (BNL)

- Nanomaterial Synthesis-by-Assembly
- Accelerated Nanomaterial Discovery
- Nanomaterials in Operando Conditions
- X-ray Nanoscience

CINT (SNL/LANL)

- Quantum Materials Systems
- Nanophotonics & Optical Nanomaterials
- In-Situ Char & Nanomech
- Soft, Biological, & Composite Materials

CNM (ANL)

- Quantum coherence by design (QIS)
- Ultrafast dynamics and non-equilibrium processes
- AI/ML-accelerated analytics and automation
- Nanoscale discovery for a sustainable energy future
- Interfaces, assembly, and fabrication for emergent properties

CNMS (ORNL)

- Soft Matter Science
- Atomic/molecular-level Manipulation & Synthesis
- Autonomous, smart experiments via AI/ML
- Understanding Heterogeneities in Quantum Materials
- Neutron nanoscience

Foundry (LBNL)

- Accelerated materials discovery
- Sustainable materials and biomaterials
- Big data (4D-STEM) electron microscopy
- Hierarchical control of energy flow

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The NSRCs unique capabilities

Each NSRC has a strategic focus that defines unique, signature instrumentation

CFN (BNL)

- Robotic nanomaterial synthesis by assembly
- In-situ and operando X-ray and electron microscopy & spectroscopy
- Nanomaterial discovery by autonomous synchrotron X-ray scattering

CINT (SNL/LANL)

- Metamaterials and nanophotonics
- Ion implantation from keV to MeV
- AI/ML and computational materials science (LAMMPS, MEMPHIS, NEXMD)
- Microelectronics and quantum device fabrication

CNM (ANL)

- Hard X-ray Nanoprobe
- Ultrafast imaging and spectroscopy
- Quantum materials characterization at ultralow temps
- Electron Microscopy (specifically dynamic imaging)

CNMS (ORNL)

- Ultrahigh-resolution STEM imaging and spectroscopy
- Atom probe tomography beyond conducting materials
- Cryo-EM for soft matter, biomaterials, and functional nanomaterials
- Autonomous synthesis and characterization platforms

Foundry (LBNL)

- Electron Microscopy (specifically 4D-STEM)
- Accelerated Materials Discovery (robots, data, Materials Project, etc)
- Bio-inspired materials design and synthesis (peptoids etc)

All NSRCs utilize expertise in synthesis, characterization, nanofabrication, and theory and modeling

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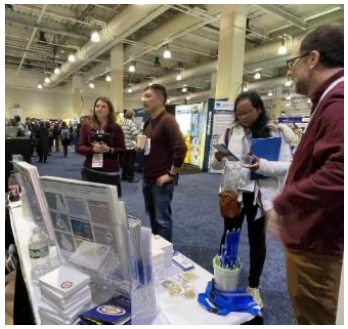
Examples of synergies and collaborations across the NSRCs

Between NSRC User Offices

- Monthly meetings between NSRC Directors and between User Program Managers
- Best practices - most efficient and effective processes for running the centers
  - Reporting
  - Outreach
  - User Meetings
  - Data collection
  - Proposal Review Process
  - Adapt COVID procedures
  - Promote remote users and self-driving labs
- Set up and manage NSRC booth at conferences
- Staff scientists participate on proposal review committees

Scientific Proposals

- BES Renew – A Collaborative Machine Learning Platform for Scientific Discovery
- BES Renew – A Digital Twin for In-Silico Spatiotemporally Resolved Experiments
- Electron Distillery



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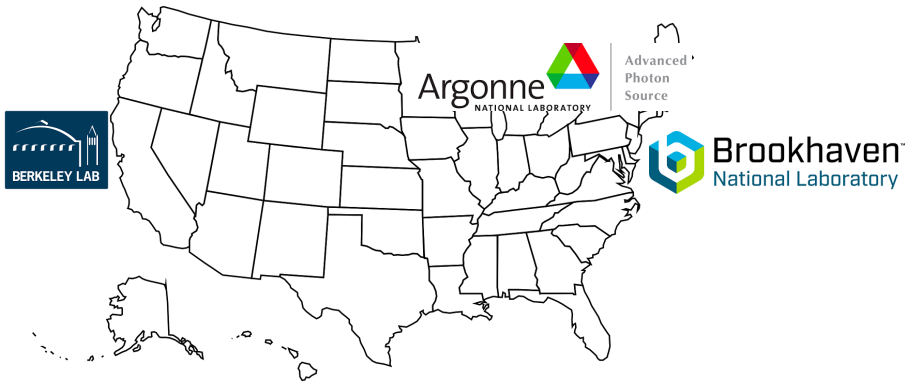
AND EQUIPMENT!

Synergies between NSRCs and Co-located User Facilities

- Collaborations with co-located facilities add uniqueness to our science and the capabilities that we can offer our users
- Examples of co-located facilities include DOE supported light sources (ALS, APS, NSLS-II) and the high-performance (HPC) computing facilities (ALCF, NERSC, OLCF)

CFN, CNM and MF are co-located with a Light Source

Enables operational partnerships, co-development of techniques, correlative imaging, collaborations on data handling, sample prep and analysis



CNM, MF and CNMS are co-located with an HPC

Collaboration on software infrastructure, AI-enabled workflows, data processing and curation

CINT (Sandia/LANL) is co-located with several NNSA facilities with capabilities in microsystems engineering, ultrafast optics, ion implantation of materials and others

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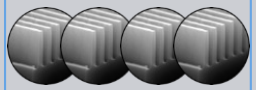
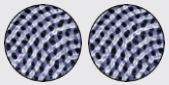
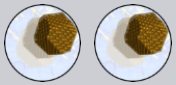
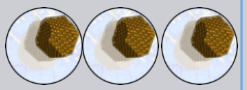
Some specific project examples of collaborations and synergies!

New equipment synergy example: NSRC recapitalization project

- NSRC-Recap fortifies capabilities in three nanoscience areas that will drive the next decade of discoveries
- NSRC-Recap is siting 17+ new instruments to align with NSRC strategic focus areas
- Brookhaven is the managing laboratory, with Chuck Black serving as the Project Director. Points of Contact at all 5 NSRCs meet at least weekly to discuss updates

	CFN	CINT	CNM	CNMS	Foundry
					
Expanding the Limits of Nanofabrication					
Accelerating Nanoscale Materials Discovery & Design					
Decoding Nanoscale Dynamics and Heterogeneity					

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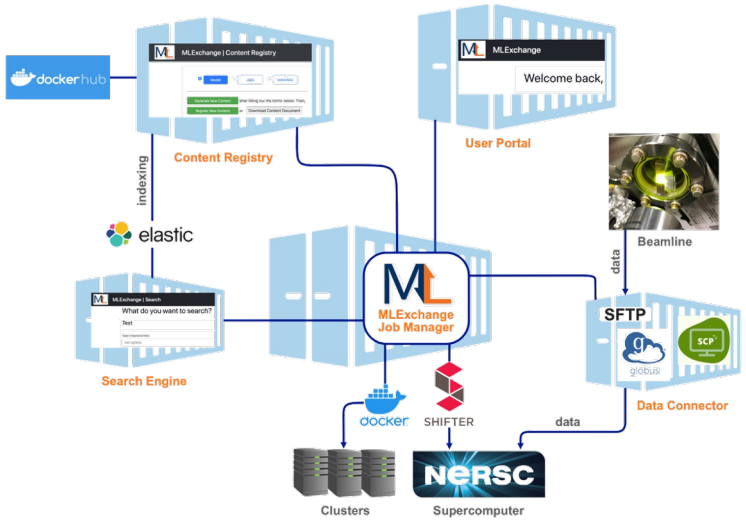
Software and data handling

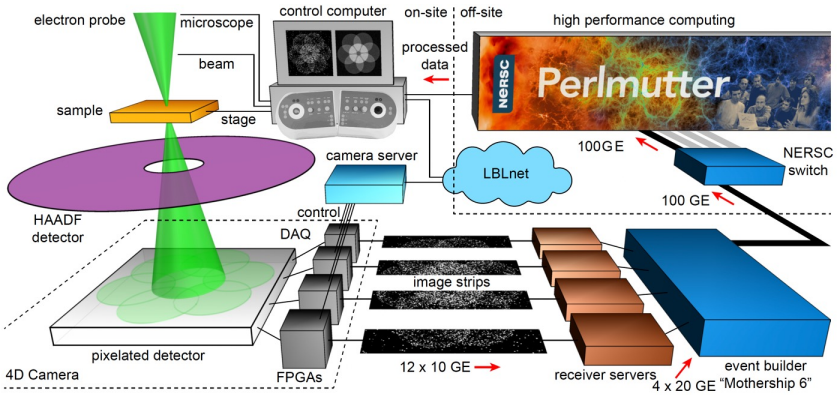
Enhancements through collaboration between NSRCs and light sources

- **MLExchange:** Open-source software infrastructure and analysis tools shared across **Foundry, CNM, CNMS and Light sources**; enabling user accessible ML analysis pipelines
- **Electron Distillery** : **Foundry-led, CNM, CFN + NERSC** collaboration to process and visualize high rate (7 TB/min) data acquisition and develop ML tools

MLExchange



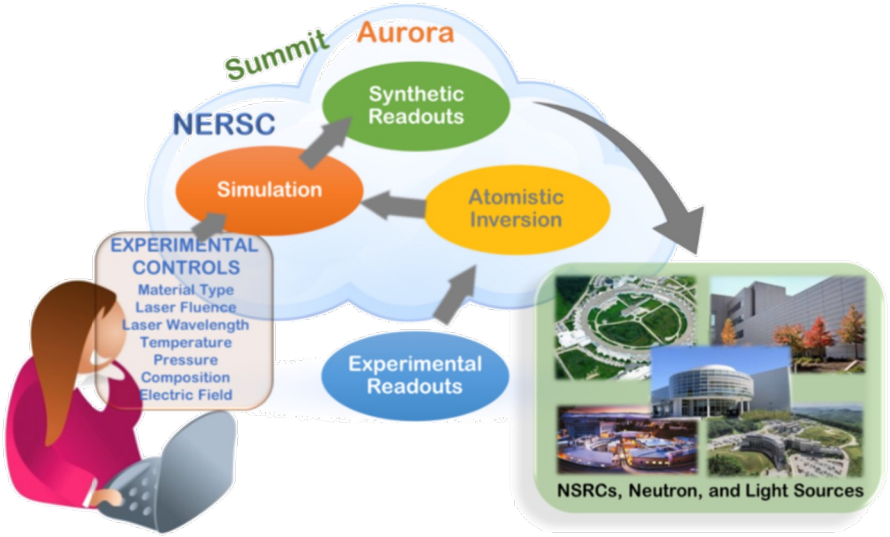
Electron Distillery

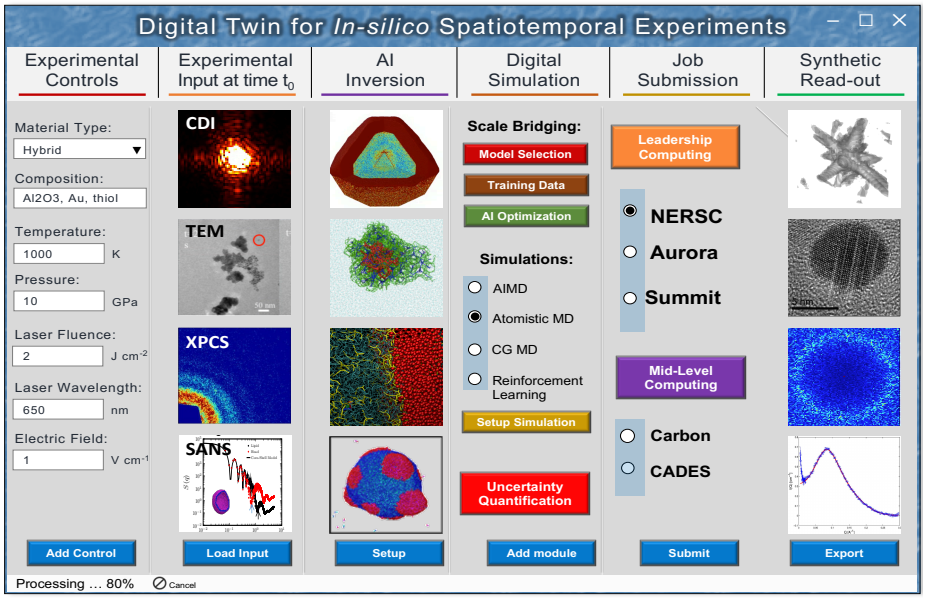


Direct connection of 100 gbps detectors to NERSC for on-stream processing

Digital Twin for Spatiotemporal Experiments

Enhancements through collaboration between NSRCs and light sources





- AI solutions to the inverse problem, i.e., information extraction from time-resolved experiments
- AI/ML Guided multi-fidelity bridging for physically accurate & efficient dynamical simulations
- Shared workflows for seamless information exchange between models and experiments

Collaboration Across Scientific User Facilities:
CNM, CNMS, MF, CFN, CINT, APS, ALS, SLAC

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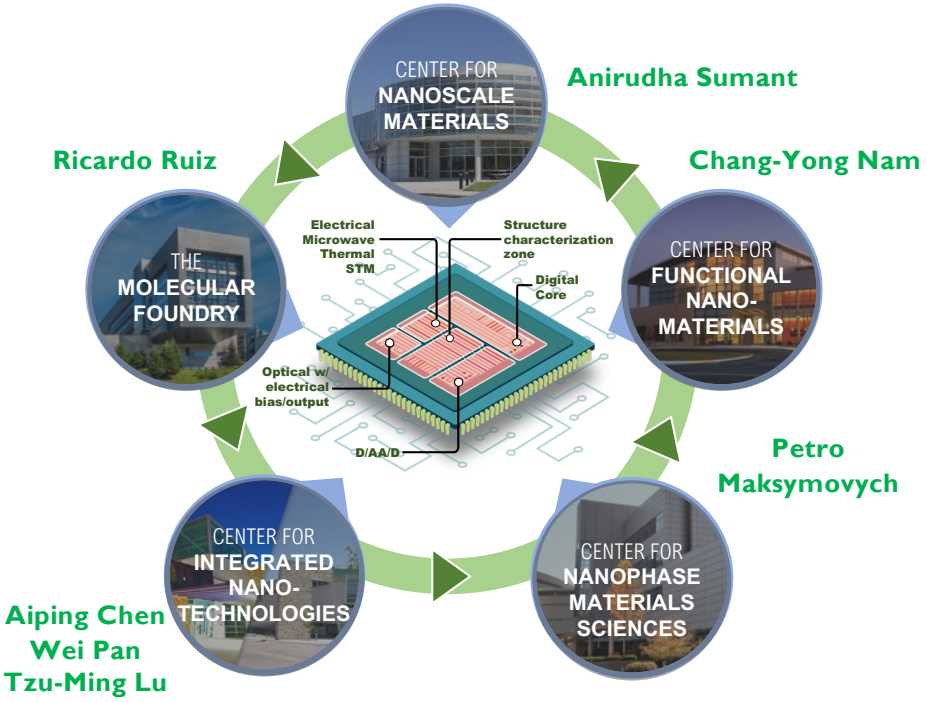
Cross-NSRC working groups to address national priorities

Example: Microelectronics

Collective resource to accelerate *CHIPS and Science Act* innovation and economic impact



Industry and University Research Needs

- Metrology, Modeling and AI for 3D Heterogeneous Integration
- Materials Synthesis
- Integration of Non-Conventional Materials and Device Architectures
- Tools for Next-Generation Lithographic Patterning
- Advanced In-Situ / Operando Characterization

Combined Capabilities, Expertise, and Facilities

- **40,000 sq. ft. of flexible, fast-turn cleanrooms** for nanofabrication and integration of early stage materials, devices and architectures
- More than **100 materials synthesis laboratories** for inorganic, organics, and hybrid composites
- More than **30 unique measurement capabilities** for *metrology, property, performance, and in-situ / operando studies*
- **Atomic to microscale modeling tools,** including AI/ML for Lab to Fab correlations
- ***Portal to other DOE*** Facilities and User Facilities

Other NSRC working groups: quantum information science, data science AI/ML, clean energy

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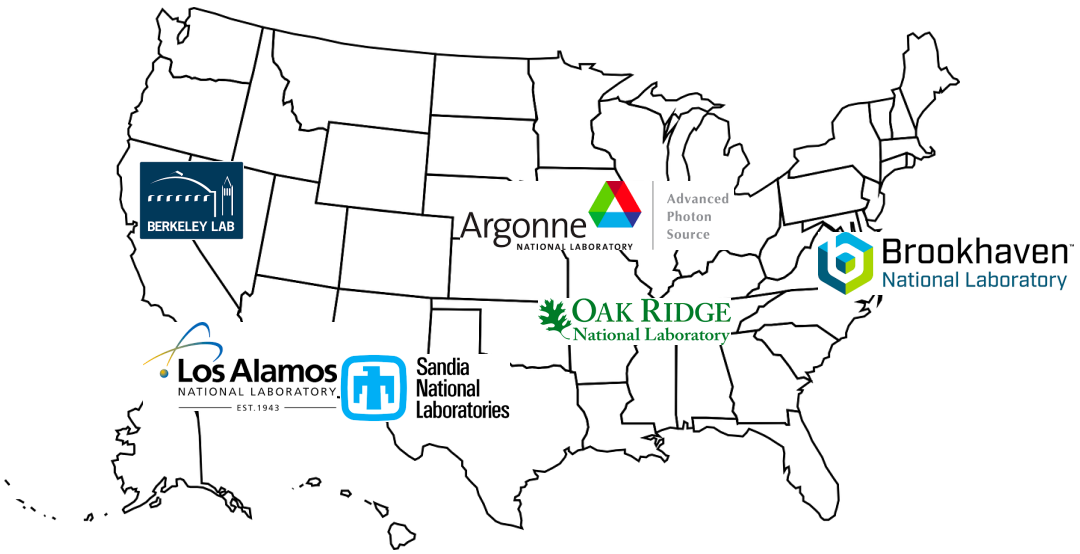
Conclusion: NSRC synergies and co-located facilities lead to increased collaboration and impact



Connecting to national priorities, the NSRCs successfully collaborate as well as operate and co-develop scientific capabilities with the DOE light sources, the HPC resources, the neutron sources and NNSA facilities

There is a strong synergy between NSRC science and other DOE facilities; clearly emphasized by co-location

We look forward to future great partnerships !

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