
BROOKHAVEN
NATIONAL LABORATORY
NSLS-II
Welcome to
Brookhaven Lab

# Brookhaven Lab Today

## Office of Science Laboratories

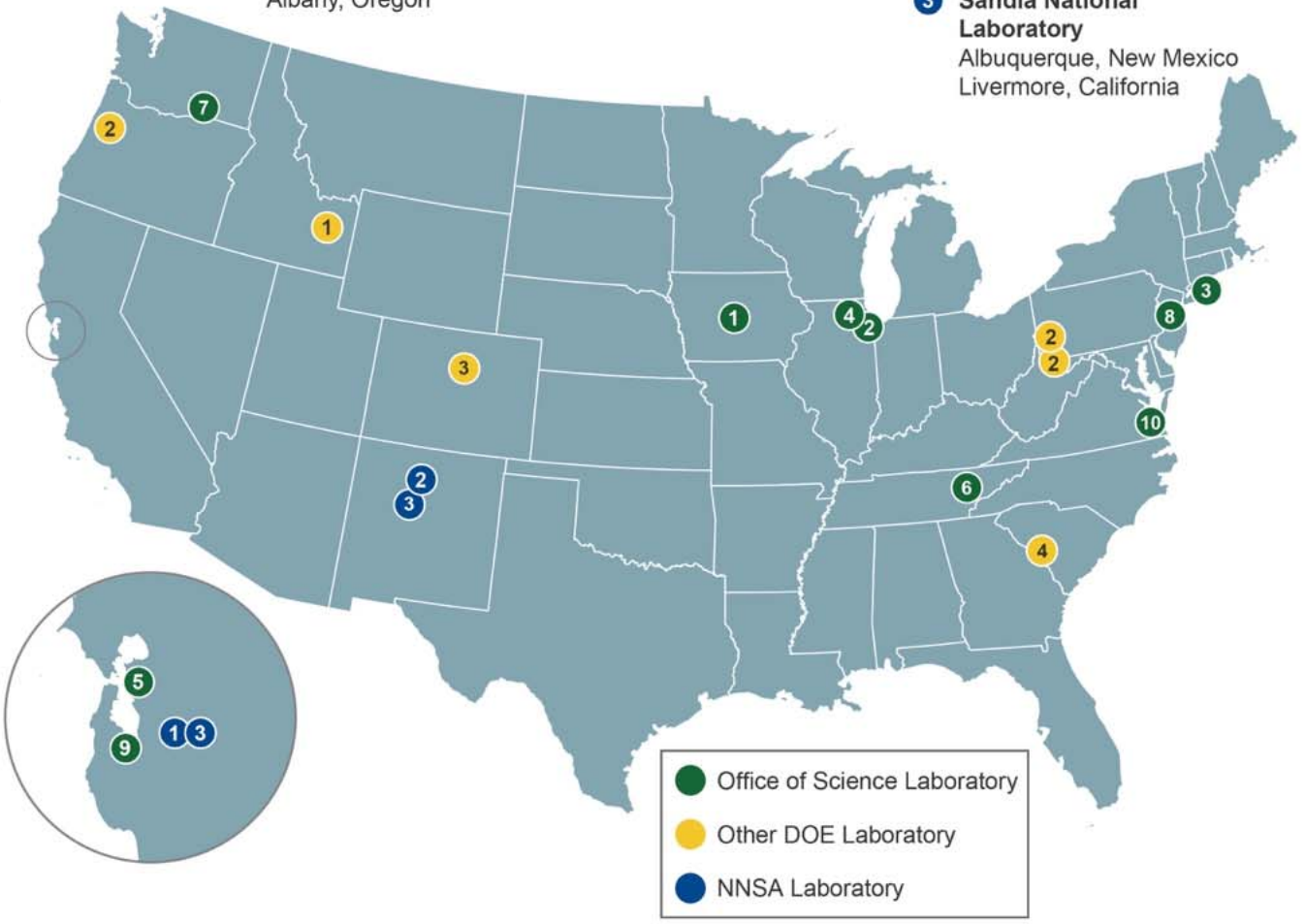
1. **Ames Laboratory**
   Ames, Iowa
2. **Argonne National Laboratory**
   Argonne, Illinois
3. **Brookhaven National Laboratory**
   Upton, New York
4. **Fermi National Accelerator Laboratory**
   Batavia, Illinois
5. **Lawrence Berkeley National Laboratory**
   Berkeley, California
6. **Oak Ridge National Laboratory**
   Oak Ridge, Tennessee
7. **Pacific Northwest National Laboratory**
   Richland, Washington
8. **Princeton Plasma Physics Laboratory**
   Princeton, New Jersey
9. **SLAC National Accelerator Laboratory**
   Menlo Park, California
10. **Thomas Jefferson National Accelerator Facility**
    Newport News, Virginia

## Other DOE Laboratories

1. **Idaho National Laboratory**
   Idaho Falls, Idaho
2. **National Energy Technology Laboratory**
   Morgantown, West Virginia
   Pittsburgh, Pennsylvania
   Albany, Oregon
3. **National Renewable Energy Laboratory**
   Golden, Colorado
4. **Savannah River National Laboratory**
   Aiken, South Carolina

## NNSA Laboratories

1. **Lawrence Livermore National Laboratory**
   Livermore, California
2. **Los Alamos National Laboratory**
   Los Alamos, New Mexico
3. **Sandia National Laboratory**
   Albuquerque, New Mexico
   Livermore, California



# Brookhaven Lab Today

## Details

- One of 17 U.S. Department of Energy national laboratories
- The Northeast's only multi-program DOE Office of Science lab
- Managed by Brookhaven Science Associates
- Fundamental research to commercialization: energy S&T, nuclear and high energy physics, bio and environmental sciences, big data and national security

## Numbers

- Employees: >2,500
- Jobs in NY State: approx. 5000
- Visitors and Users: 4,000 per year (600+ from Stony Brook)
- Grad/Undergrad students on payroll: 400
- Total funding for FY 2020: ~$740 million

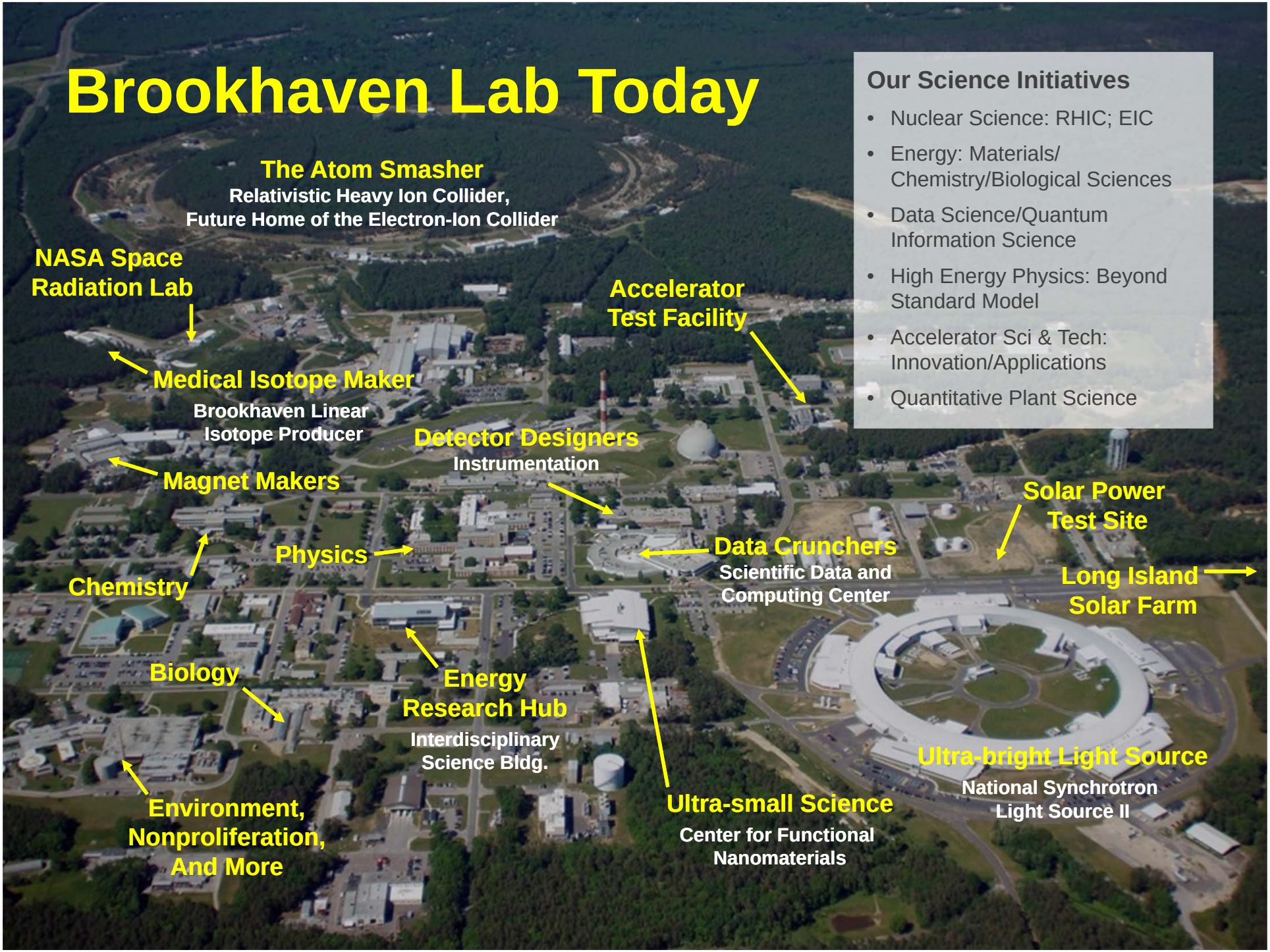
## Key partnerships

- DOE
- Stony Brook University, Battelle
- New York State

Doon Gibbs
BSA President,
Brookhaven Lab
Director

**Robert Tribble**
Deputy Director
For Science &
Technology

Jack Anderson,
Deputy Director
For Operations


Brookhaven Lab Today
The Atom Smasher
Relativistic Heavy Ion Collider,
Future Home of the Electron-Ion Collider
NASA Space Radiation Lab
Medical Isotope Maker
Brookhaven Linear Isotope Producer
Magnet Makers
Chemistry
Physics
Biology
Environment, Nonproliferation, And More
Detector Designers
Instrumentation
Energy Research Hub
Interdisciplinary Science Bldg.
Accelerator Test Facility
Data Crunchers
Scientific Data and Computing Center
Ultra-small Science
Center for Functional Nanomaterials
Solar Power Test Site
Long Island Solar Farm
Ultra-bright Light Source
National Synchrotron Light Source II
Our Science Initiatives
• Nuclear Science: RHIC; EIC
• Energy: Materials/ Chemistry/Biological Sciences
• Data Science/Quantum Information Science
• High Energy Physics: Beyond Standard Model
• Accelerator Sci & Tech: Innovation/Applications
• Quantitative Plant Science

# Discovery and Innovation, Serving the Nation

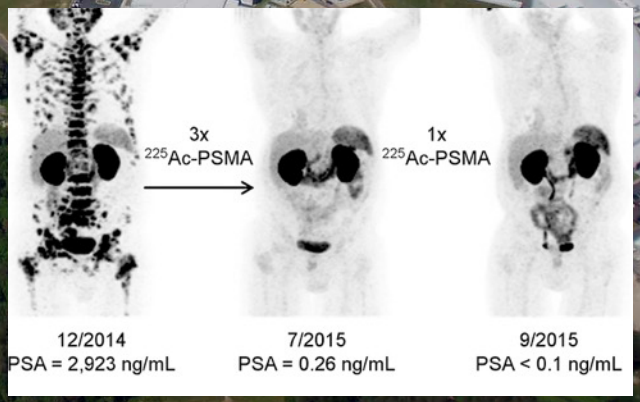
## Nobel Prizes in Physics and Chemistry

1957 1976 1980 1988 2002 2003 2009

## Some billion-dollar impacts at Brookhaven Lab

- Tc-99m for imaging and fighting cancer
- Cleaner-combusting oil burners: $25B savings, $CO_2$ reduction
- PET scan radiotracers used to study the nervous system and image cancer

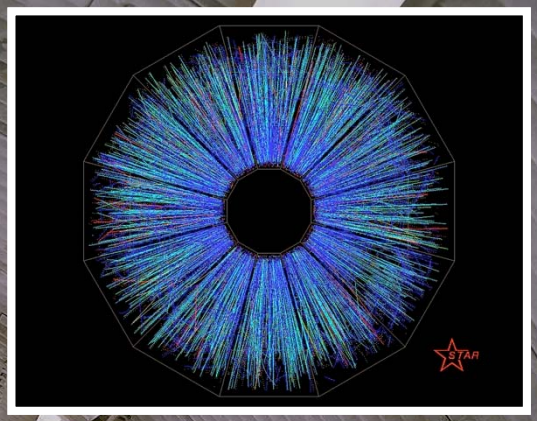
## Actinium-225



# Inside RHIC

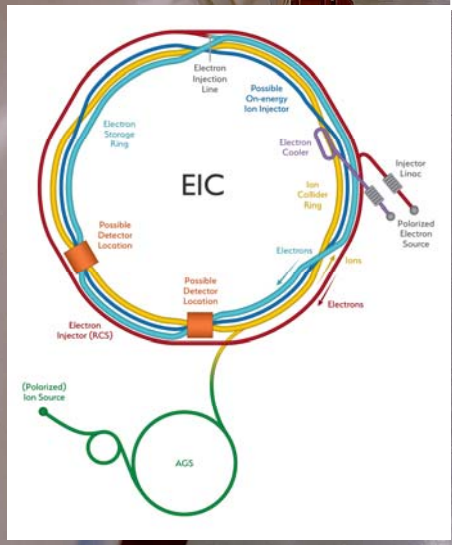
## Unlocking the mysteries of matter and mass, and why the universe works the way it does

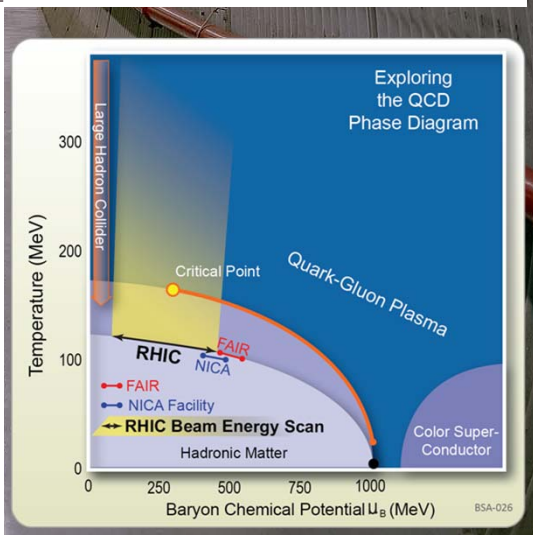
- 1,000+ scientists, engineers, and students from around the world
- Used to explore the "strong force" and 0.00001 seconds after the birth of the universe
- Discovered quark-gluon plasma, a "perfect" liquid at 7 trillion degrees Fahrenheit



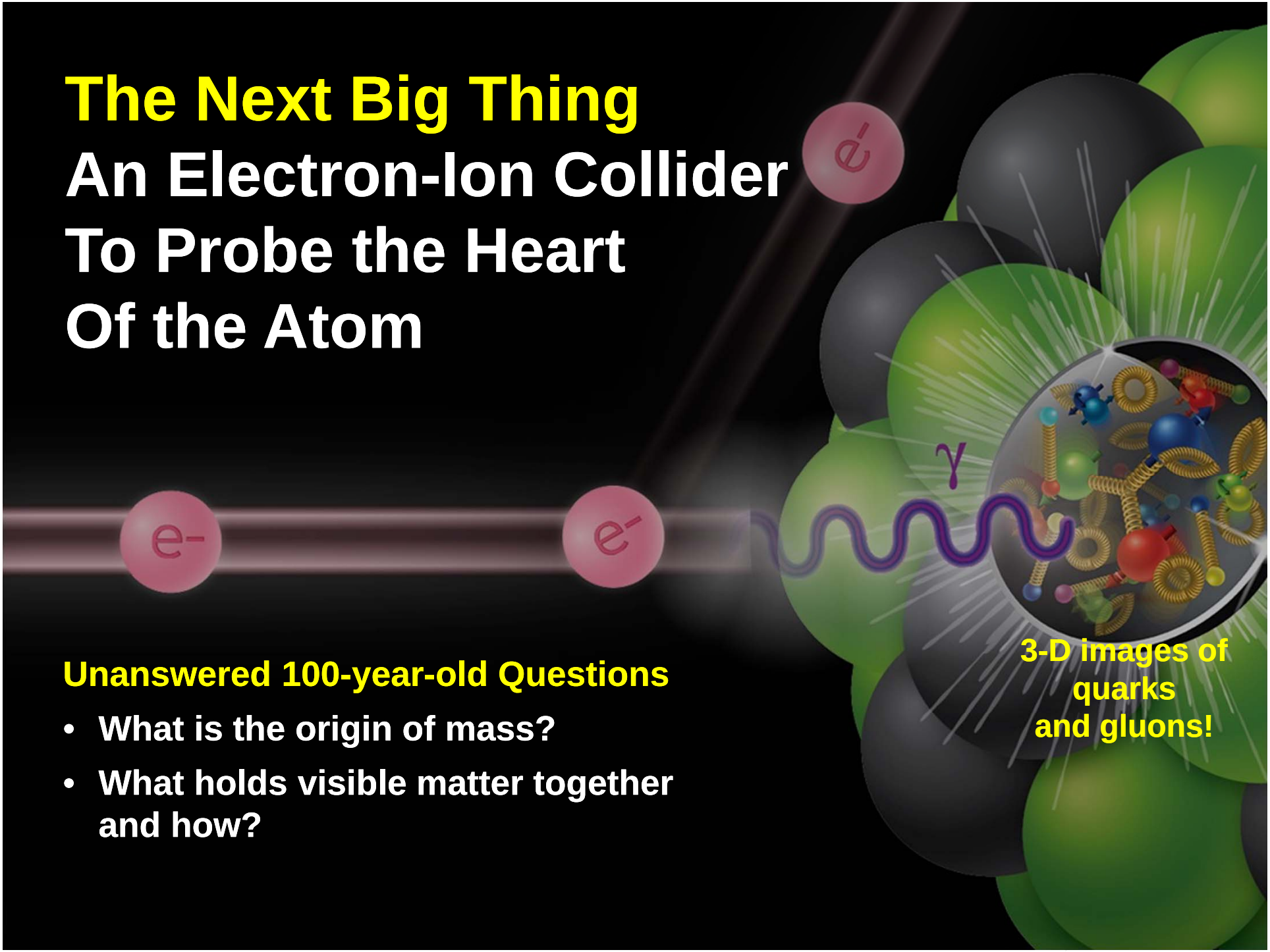

## Strategy for the future

- Measure the extraordinary properties of the perfect liquid
- Applications of nuclear science
- Transition from RHIC to EIC to learn what's at the heart of all visible matter



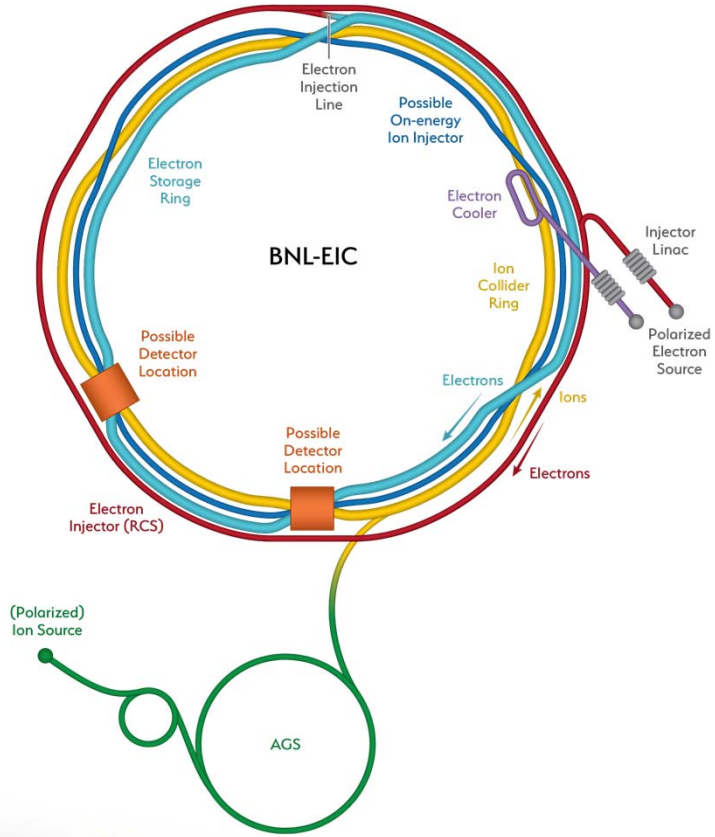
# The Next Big Thing
# An Electron-Ion Collider To Probe the Heart Of the Atom




**Unanswered 100-year-old Questions**

- **What is the origin of mass?**
- **What holds visible matter together and how?**

# Electron-Ion Collider Concept

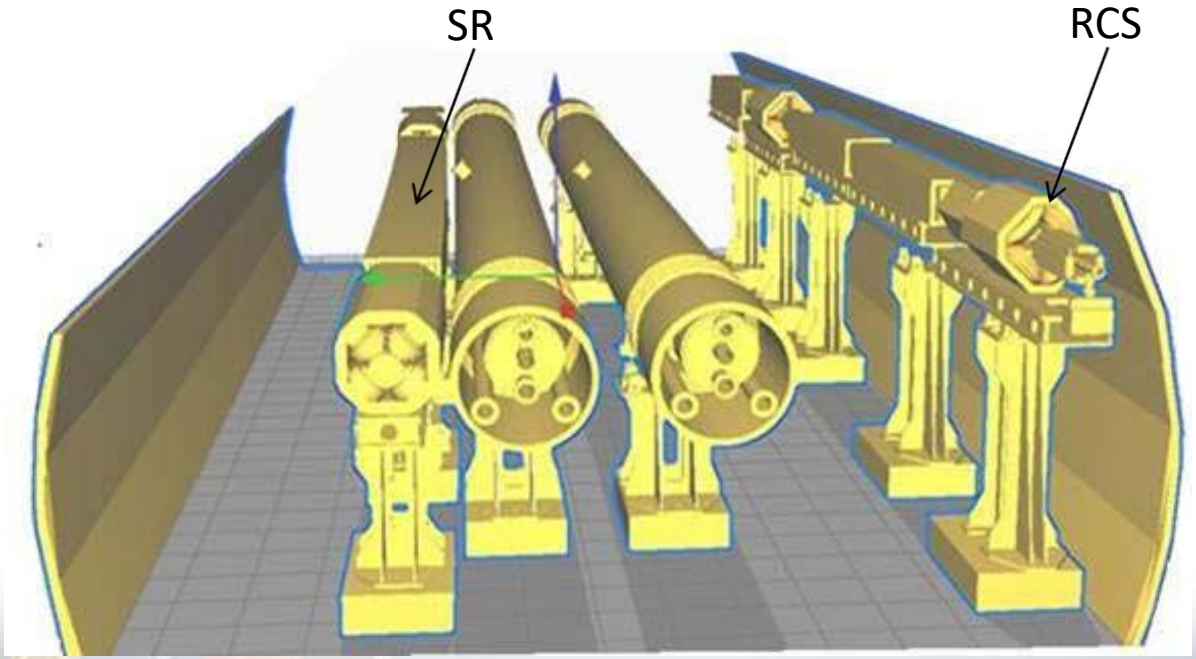



- Hadron Storage Ring
- Hadron Injector Complex
- Electron Storage Ring
- Electron Injector Synchrotron
- Electron Cooler
- Possible On-energy Hadron Injector Ring

# EIC Machine in the RHIC Tunnel

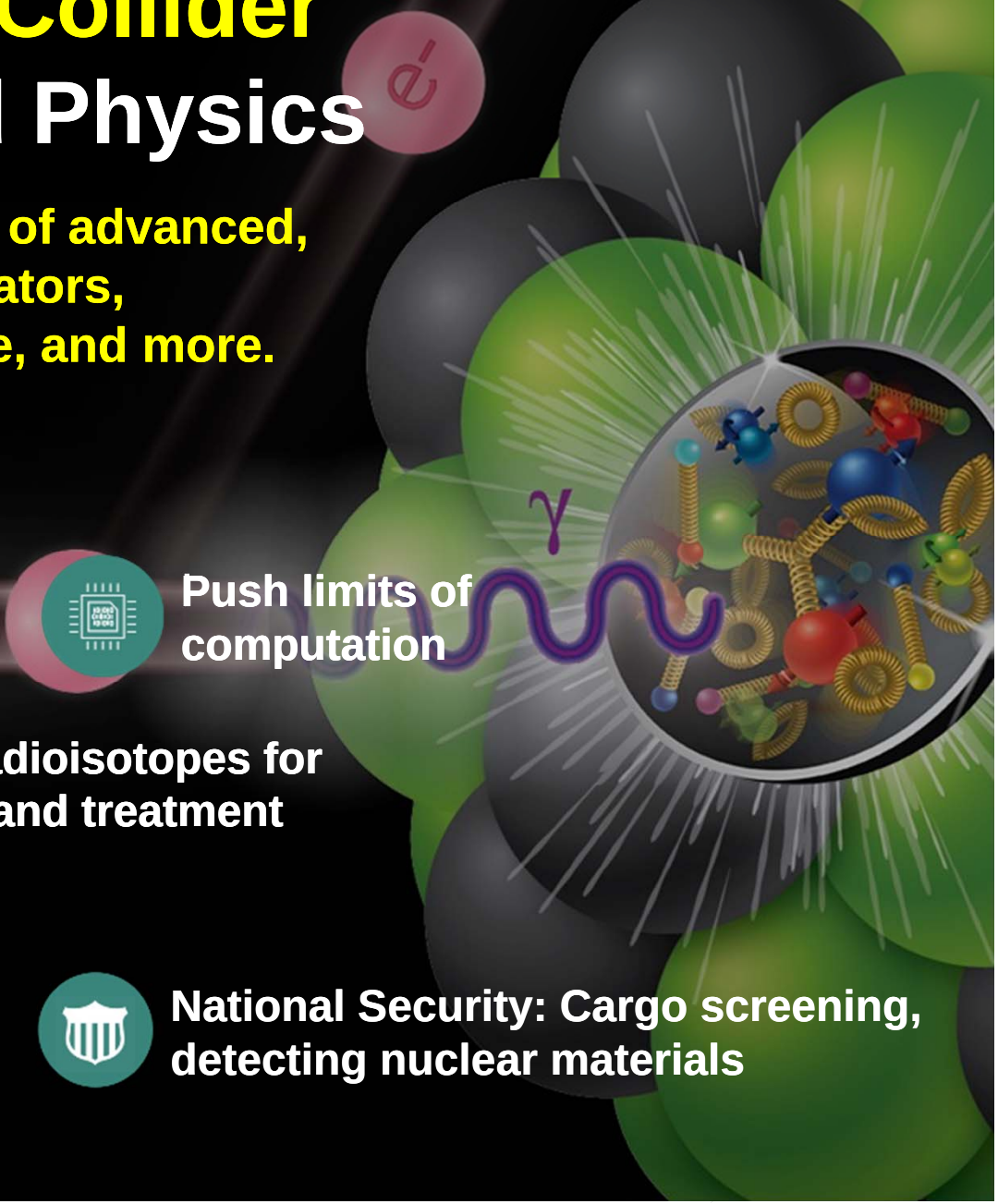
- Rapid Cycling Synchrotron (RCS) for electrons and Electron Storage Ring (SR) fit into the existing RHIC tunnel

- Two existing detector halls available for interaction regions and detectors



# An Electron-Ion Collider
## Benefits Beyond Physics

**R&D is pushing the evolution of advanced, more energy-efficient accelerators, computation and data science, and more.**




**Attack cancer cells**

**Push limits of computation**

**Produce radioisotopes for diagnosis and treatment**

**Advance energy solutions**

**National Security: Cargo screening, detecting nuclear materials**

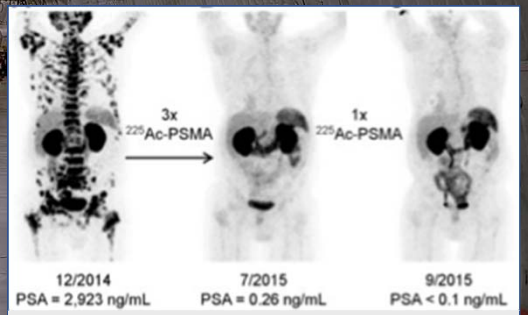
# RHIC's Accelerator Complex

## Space travel

- At the NASA Space Radiation Laboratory, particle beams from the RHIC accelerator complex simulate cosmic radiation to study health risks associated with longer missions in space and to Mars!

## Radioisotopes—medical treatments—that save lives

- Brookhaven Linear Isotope Producer for medical isotopes not commercially available
  - We produce half the United States' strontium-82 for generators to assess heart health
  - Collaborating on research for cancer therapy: Can produce Actinium-225, an "alpha-emitter" for noninvasive treatment, kills cancer cells with minimal damage to surrounding tissue



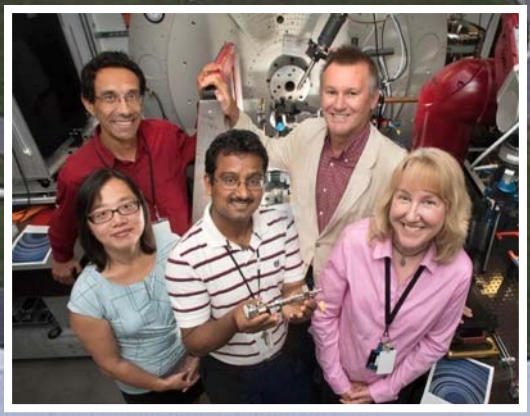

*Actinium 225 (alpha emitter) treatment of metastatic cancer*

## Particle detectors for health, national security

- Brookhaven experts have built detectors for countless experiments, PET detectors to diagnose disease, and radiation detectors that contribute to our nation's security

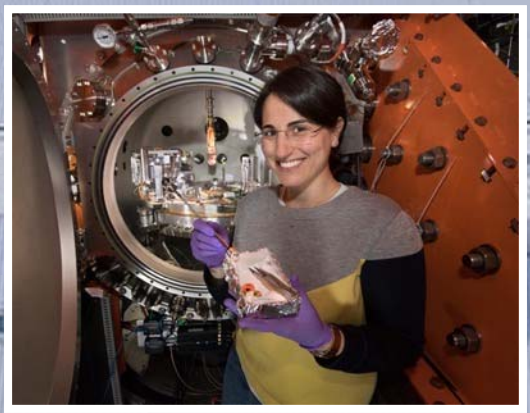
# At NSLS-II

**The brightest light source of its kind, for unprecedented capabilities, advances**



**Research for energy challenges**

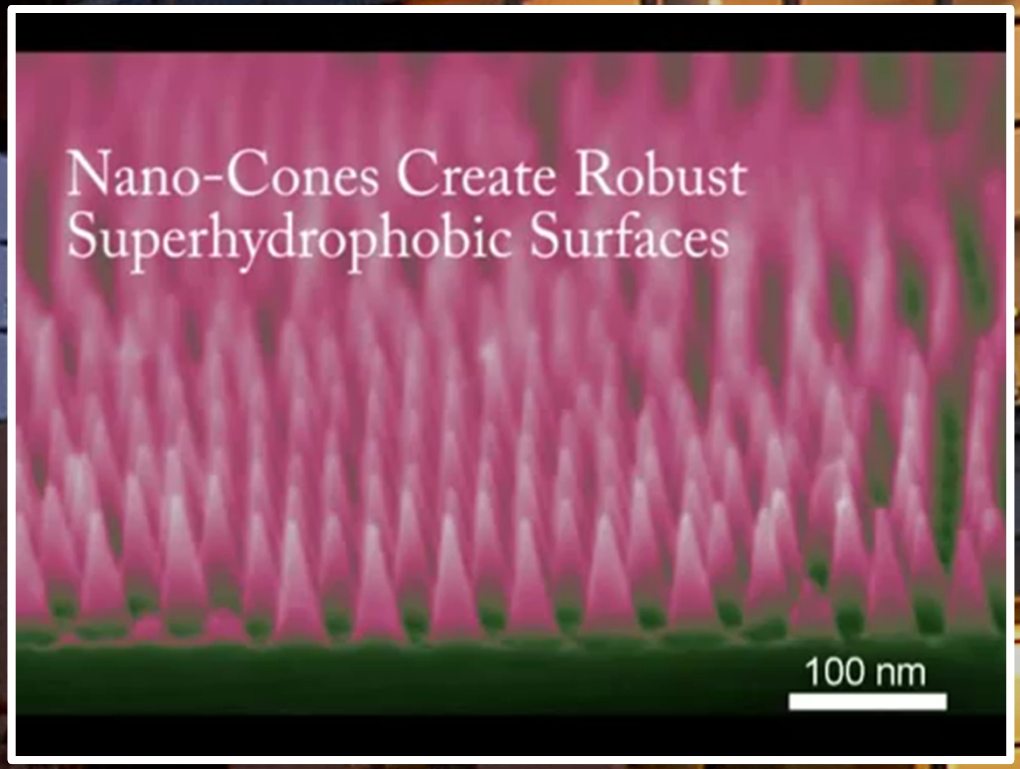
**Studying proteins, viruses to fight disease, including COVID-19**



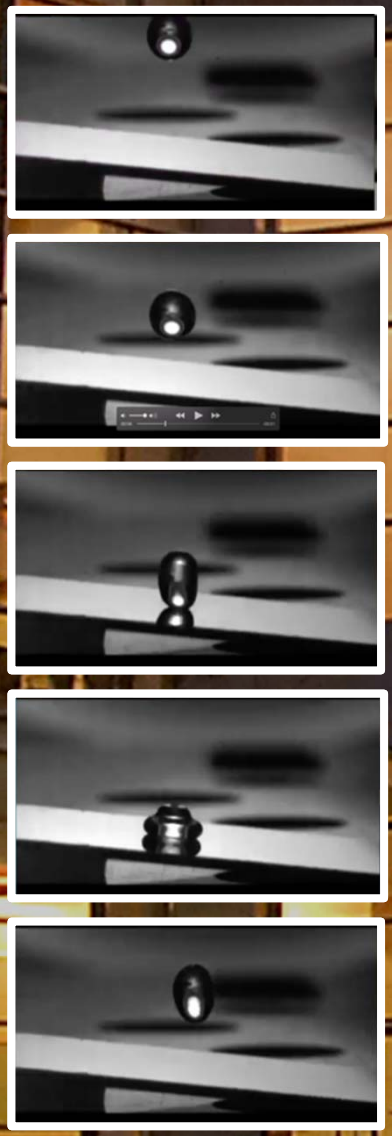
**Now with a state-of-the-art CRYO-EM facility**

# At the CFN

**Research at the ultra-small nanoscale for big advances in energy, national security, more**




Also available on YouTube (http://bit.ly/bnl-hydrophobic)



# Quantum Computing, ‘BIG Data’ for Science And Beyond

A powerhouse for storage and processing

Quantum: Materials and data science

AI/ML for drug discovery – COVID-19

A competitive advantage today—and tomorrow

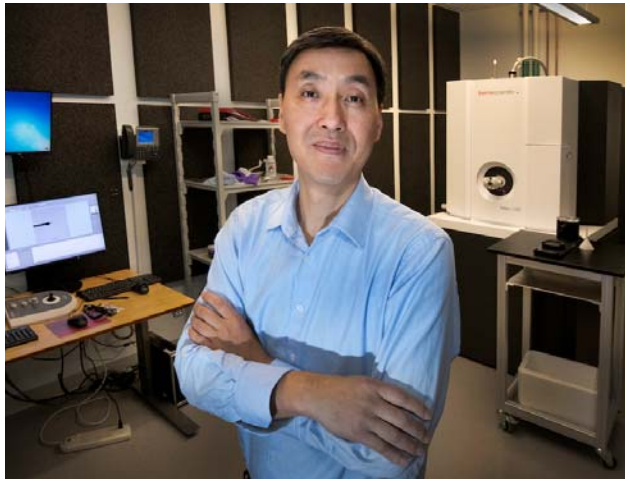
# Aligning Assets to Fight COVID-19

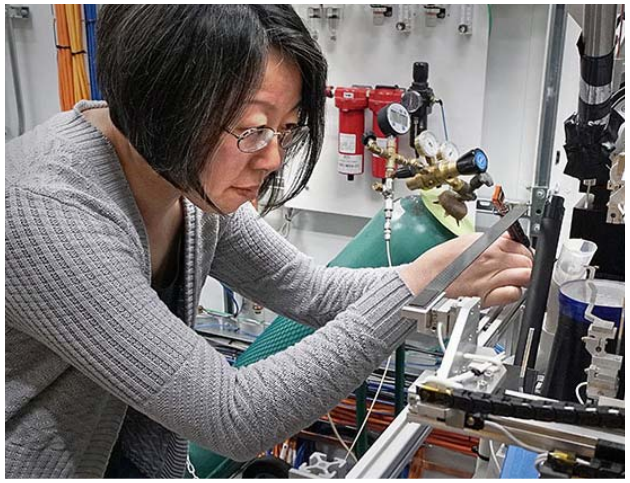
Characterizing atomic-level structure of viral components at NSLS-II

Studying the virus's proteins with cryo-electron microscopy at Laboratory for BioMolecular Structure

Computational approaches:

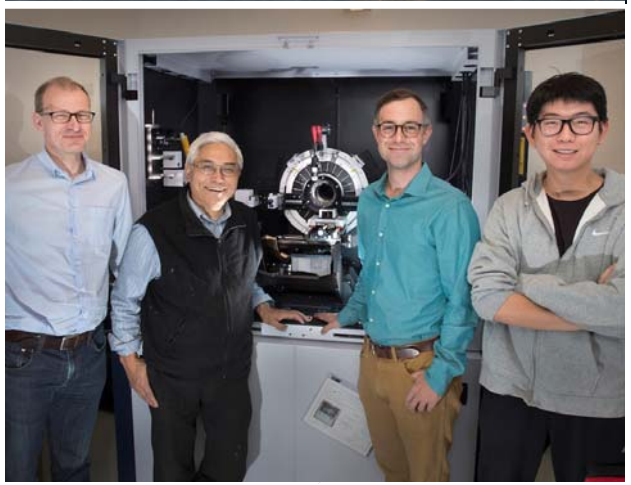
- Narrowing the search for drugs
- Tracking research efforts
- Modeling disease spread





# Renewable Energy and Energy Storage

- Long Island Solar Farm and Northeast Solar Energy Research Center on site
- National Offshore Wind Research and Technology Center
- Grid analysis and innovation
- Exploring materials for energy storage to understand, predict, and control mechanisms



- Basic Research to build the bridge to the post-NISQ era.
- Full-stack superconducting modules and clusters linked by microwave-to-optical quantum communication.

C²QA
Co-design Center for Quantum Advantage

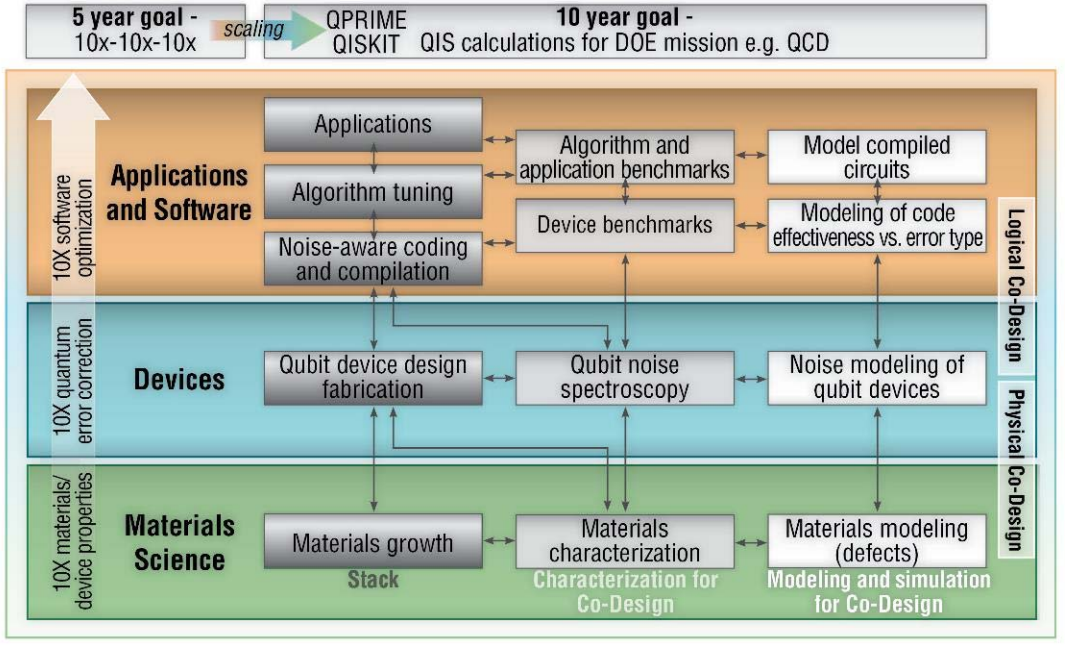
# Co-design Center for Quantum Advantage (C²QA)

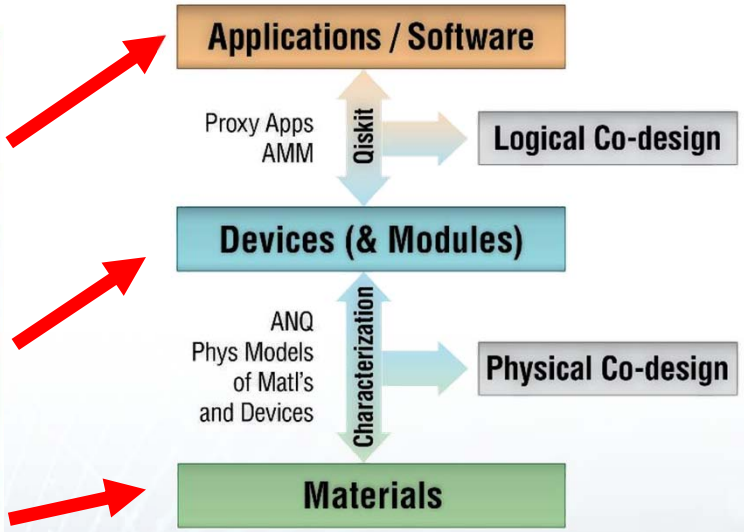
**BROOKHAVEN NATIONAL LABORATORY** https://www.bnl.gov/quantumcenter/

# Team Structure: Three Thrusts + Cross-cutting Co-Design

**Approach:** *Quantum* co-design to address immature technology challenges across the system stack. We adopt a full-stack approach encompassing the logical, physical device layer, and materials.

**Team and Execution:** Interdisciplinary team integrating leading expertise in applications, algorithms, software, architecture, devices, and fundamental materials science from across academia, industry and national labs. Project management to focus on teamwork/integration.

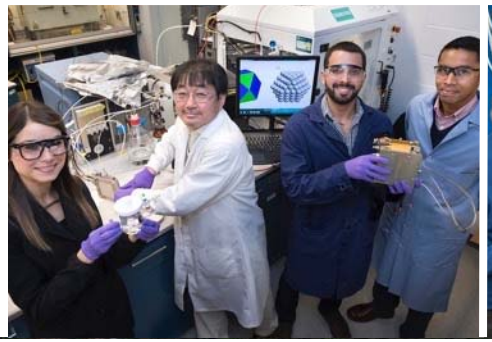



*See proposal pages 2-3*

# Students Today, Scientists Tomorrow

**30,000+ Long Island students in grades 1–12**
**350+ college students and professors**

# Looking to the Future

Brookhaven National Laboratory

## TEN-YEAR CAMPUS VISION

Delivering the next decade of science while transforming the Laboratory Campus with a diverse investment portfolio

Federal

Focus key future Federal investment in additional core building renovation to enable the scientific agenda

Indirect

Make research safe and cost effective by downsizing the campus and demolishing old buildings

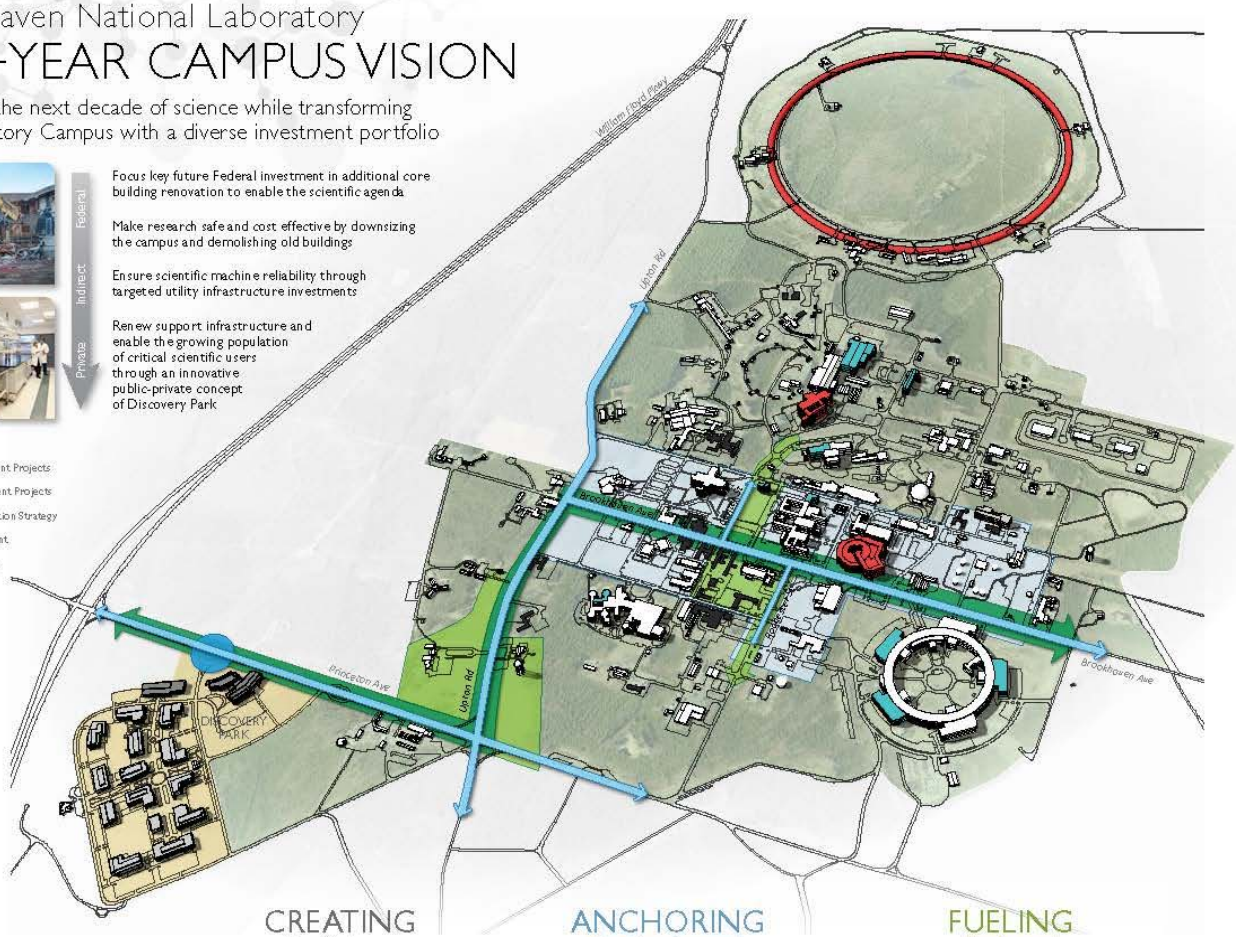
Ensure scientific machine reliability through targeted utility infrastructure investments

Private

Renew support infrastructure and enable the growing population of critical scientific users through an innovative public-private concept of Discovery Park

KEY

- Federal Investment Projects
- Indirect Investment Projects
- Footprint Reduction Strategy
- Private Investment
- Existing Building




**CREATING** the Gateway

**ANCHORING** the Development

**FUELING** the Impact

| Public-Private Partnership Investment Phases | Federal Indirect | Incentivized Partnership | Private |
|---|---|---|---|
| | ▶ Roundabout<br>▶ New Security Portal<br>▶ Phased Demolition | ▶ Utilities<br>▶ Entrance Building with Initial Office Component<br>▶ Housing<br>▶ Transportation | ▶ Technology Incubation<br>▶ Private Collaboration Facilities<br>▶ Community/Economic Development |

## DISCOVERY PARK

A public-private partnership

**SCIENCE MISSION**

| Creates | Results |
|---|---|
| New general purpose administrative, user processing, conference & collaboration space, and high density housing | Enables demolition of 300,000 SF of old inadequate wood buildings<br>Improves space utilization by 15%<br>Eliminates $34M of repair and ESH legacy deficiencies<br>Provides user amenities and renewed housing to attract the growing scientific user population<br>Opportunity for scientific partnerships and Technology Transition |

**COMMUNITY IMPACT**

| Creates | Results |
|---|---|
| A new "front door" with community access and visibility, energy showcase, STEM education and student engagement | Expands opportunities for community outreach, engagement and highlighting the technology mission and value<br>Grows the current impact of 35,000 students in STEM education programs<br>Grows a critical mass of people and activity that enables user services<br>A "sense of place" to attract young scientists |

**ECONOMIC DEVELOPMENT**

| Creates | Results |
|---|---|
| Energy test bed<br>Private user office and workspace<br>Technology incubation | Leverage the NYS investment and the BNL research agenda in energy for the Northeast Region<br>Enable colocation of partner facilities such as the proposed New York Center for Grid Innovation (NY CGI)<br>Regional economic development with new companies and new product development in key areas of research<br>BNL engagement in the emerging Long Island BioTech Cluster<br>Technology Incubation |

# Thank you


BROOKHAVEN
NATIONAL LABORATORY
70 YEARS OF DISCOVERY
A CENTURY OF SERVICE