



# Vision and Strategy for BNL

John Hill, *Deputy Director for Science and Technology*

CAC

Oct 12<sup>th</sup> 2023





# About Me

Grew up in the UK

- Lived in Florida for six months when I was eight
- Went to school in London
- Did my PhD at MIT
- Did my thesis work at BNL
- Got a postdoc position at BNL
- Did research for 25 years
- Became Director of NSLS-II in 2015
- Became DDST in July 2023





# Brookhaven



NASA Space  
Radiation Lab

Relativistic Heavy Ion Collider,  
future Electron-Ion Collider

Brookhaven Linac  
Isotope Producer

Energy,  
Environmental &  
Climate Sciences

Accelerator  
Test Facility

Northeast  
Solar Energy  
Research Center

Superconducting  
Magnet Division

Physics

Instrumentation

Computational  
Science

Long Island  
Solar Farm

Chemistry

Biology, More

Interdisciplinary  
Science Bldg.  
for Energy

Center for  
Functional  
Nanomaterials

National Synchrotron  
Light Source II

Environment,  
Nonproliferation,  
and More

Lab for BioMolecular  
Structure (Cryo-EM)



# Enduring Priorities and Science Initiatives

Brookhaven's enduring priorities:

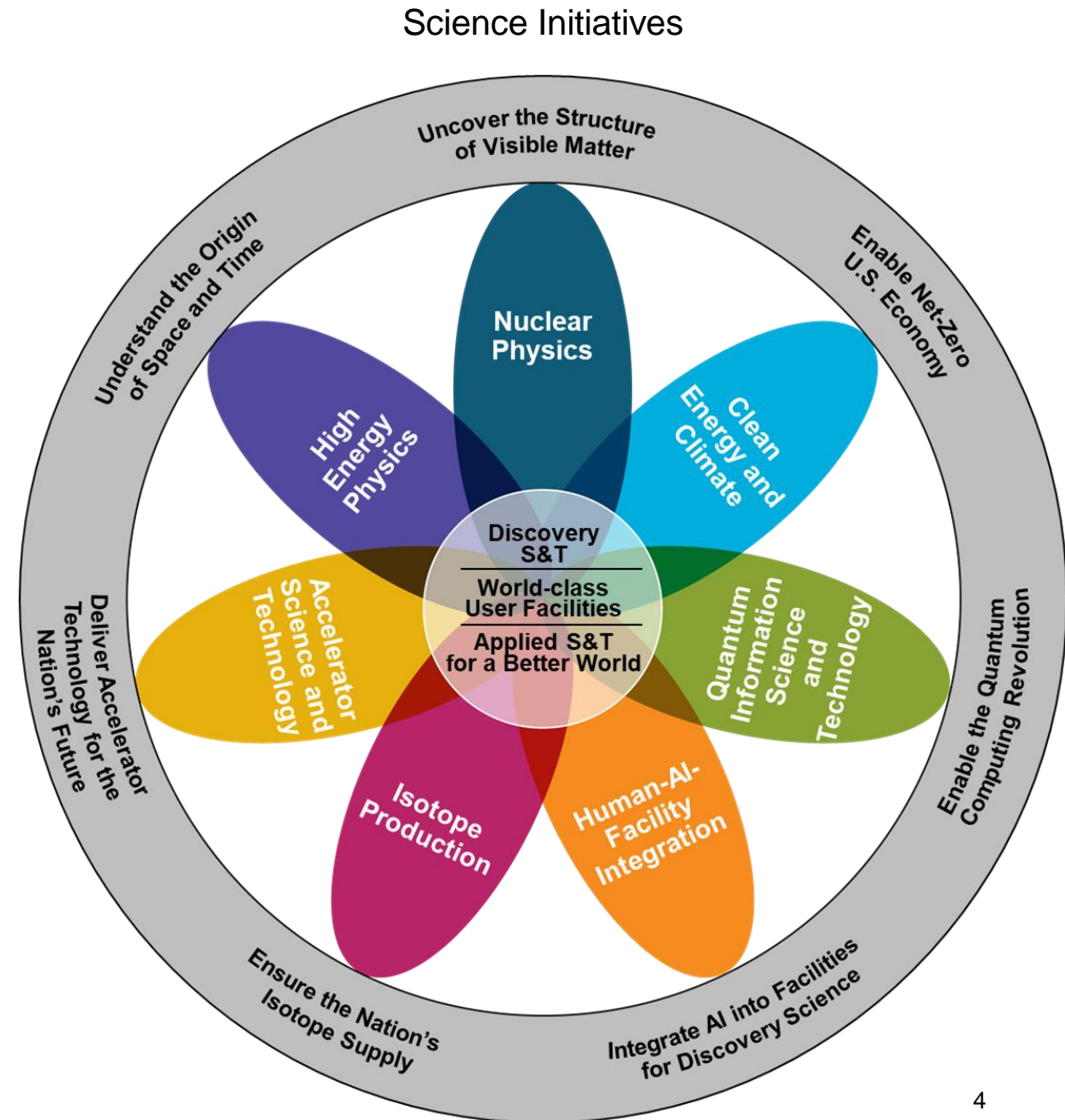
- Discovery science and technology
- Transformational user facilities, including accelerator science and technology
- Applications of the Lab's capabilities to new opportunities, e.g., clean-energy/climate deployment, national security solutions, isotopes

Enabled by:

- Safe, efficient, and secure operations
- Diversity, equity, and inclusivity

Enhanced by DOE, national lab, NYS, university, industrial, and international partners

A Passion for Discovery



# Initiatives at BNL

- The structure of visible matter
- Clean Energy and Climate
- Human-AI- Facility Integration
- Quantum information science
- Understanding the origins of Space and Time
- Accelerator science and technology
- Ensure the Nation's isotope supply

# The next decade

These initiatives will evolve as the Nation's needs evolve. The new BNL management team will work with the rest of the team to create a new strategic vision for the lab: Where are we going? Why are we going there and how will we get there?

Not a dramatic departure – BNL is successful and growing – but looking for a coherent vision for the lab into the next decade:

- 1) EIC is and will remain our number 1 priority
- 2) A future upgrade for NSLS-II
- 3) A coherent vision for data science at BNL
- 4) Renewed energy behind the development of Discovery Park
- 5) Scientifically emerging areas including:
  - 1) Quantum – networks and computing
  - 2) Bio-preparedness
  - 3) Microelectronics

Next slides discuss one of these as an example: Microelectronics

# Microelectronics and BNL





# Microchips are everywhere....



# ..and they are in the news a lot:

≡ **CNN BUSINESS** Markets Tech Media Success Perspectives Videos

## Some manufacturers have less than 5 days' supply of computer chips, Commerce Department warns

By Clare Duffy, CNN Business  
Updated 5:08 PM EST, Tue January 25, 2022



≡ **The New York Times**

## *U.S. Pours Money Into Chips, but Even Soaring Spending Has Limits*

Amid a tech cold war with China, U.S. companies have pledged nearly \$200 billion for chip manufacturing projects since early 2020. But the investments are not a silver bullet.

Advertisement

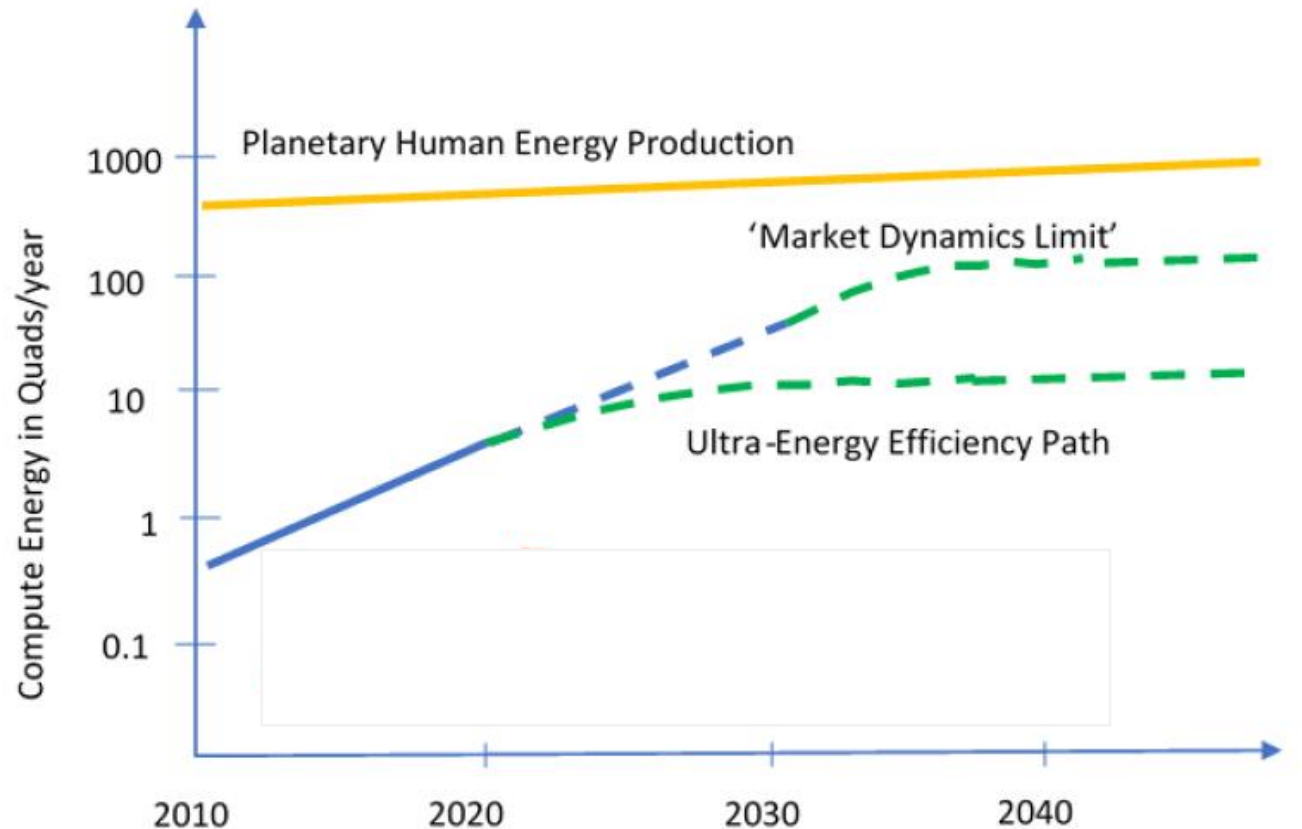
≡ **CNN BUSINESS** Markets Tech Media Success Perspectives Videos

MARKETPLACE  
**ASIA**

## The US-China chip war is spilling over to Europe

By Michelle Toh, CNN Business  
Published 12:26 AM EST, Fri November 25, 2022

# But energy use by microchips is spiraling...

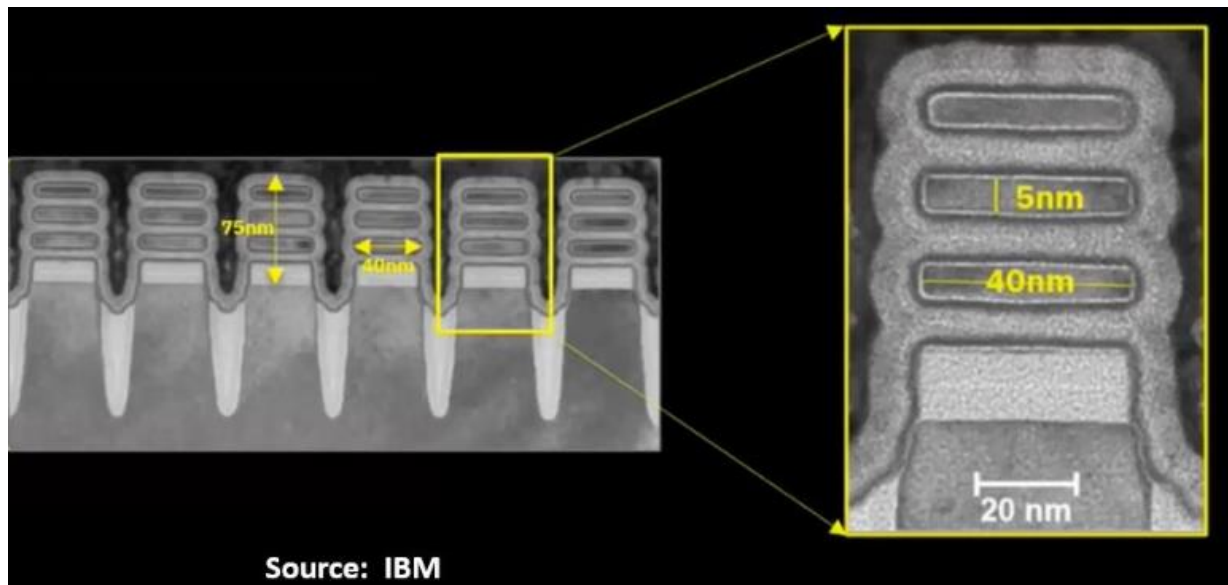


SOURCE: SRC/SIA 2021

If current trends were to continue, microchips would use a significant fraction of the world's energy production by 2035



# ..and the transistors are so small now that is causing other problems



Latest transistors have features a few atoms across and this is causing problems:

- Approaching limits of what it is even possible to make
- Defects are more difficult to control
- Stops working as a transistor
- Fails more easily

# What tools do we need?

We need understand the materials science behind these tiny structures to improve the existing technologies and to go beyond them in next generation technologies

But how can you “see” something that is only a few 10’s of atoms across?

# What tools do we need?

We need understand the materials science behind these tiny structures to improve the existing technologies and to go beyond them in next generation technologies

But how can you “see” something that is only a few 10’s of atoms across?

**Answer** : With very intense, very focused x-ray beams produced by a “synchrotron”

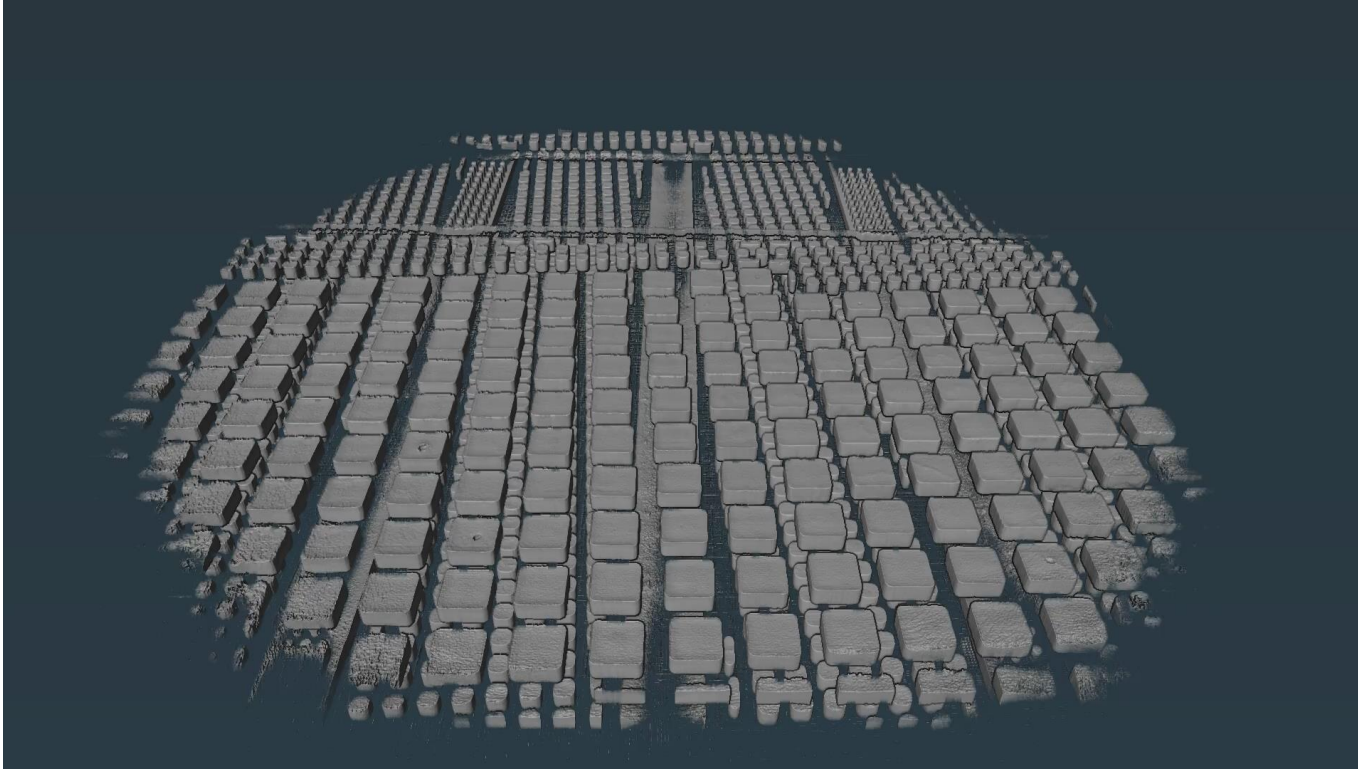


# National Synchrotron Light Source II



- User facility for visiting researchers
- Broad range of materials **characterization tools**
- World leader in “**nanoscale x-ray imaging**”

# 3D Imaging of Microelectronics

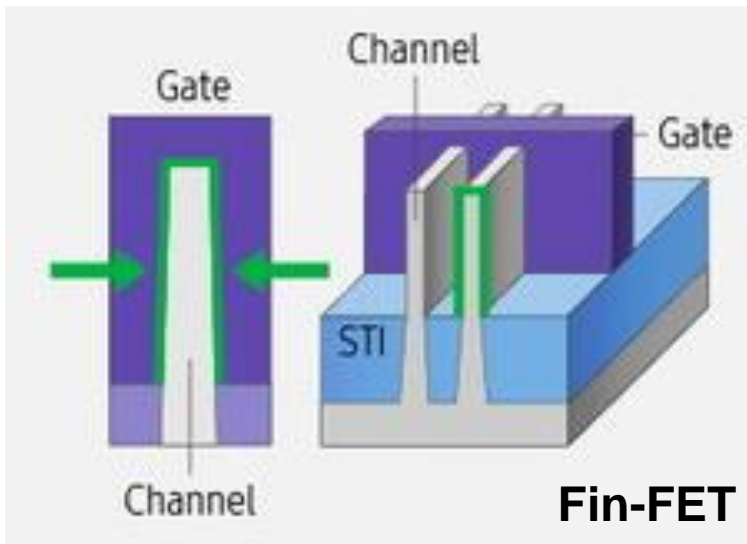
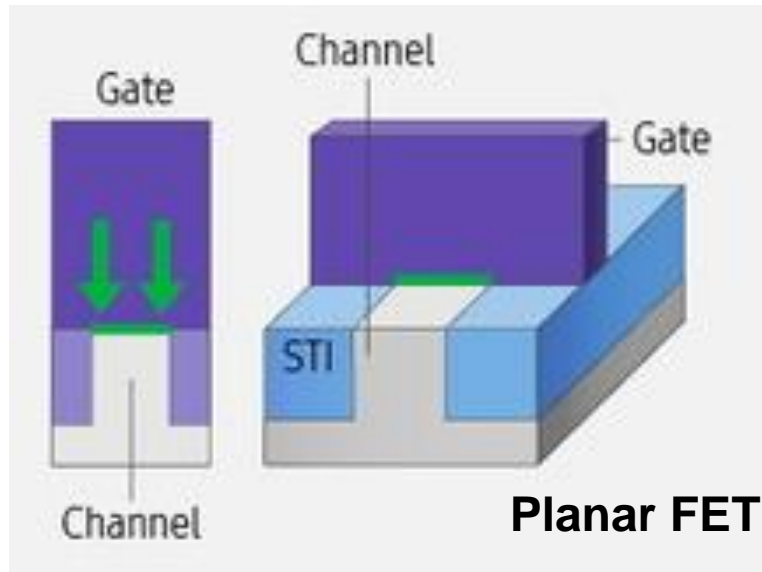


Lensless 3D imaging of integrated circuits with hard X-rays

Data taken at the APS

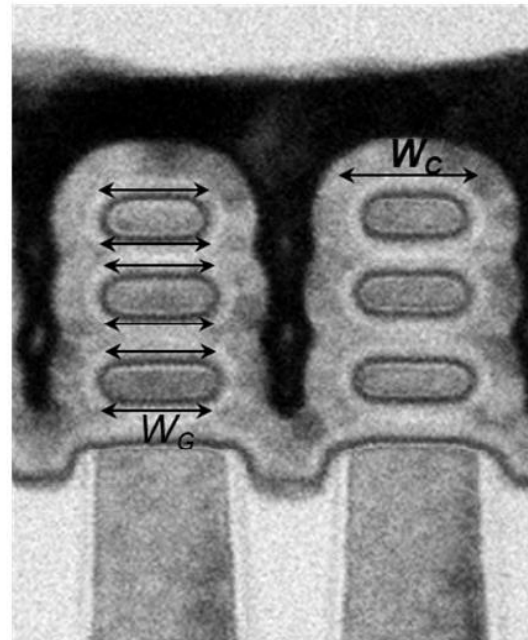
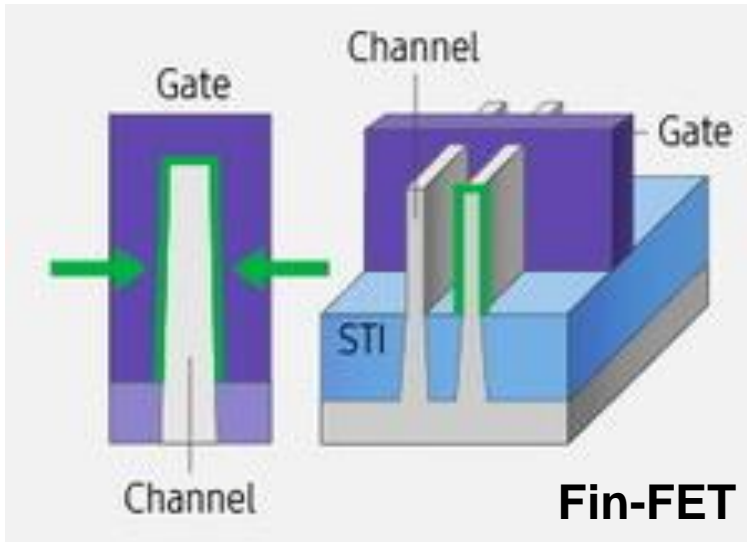
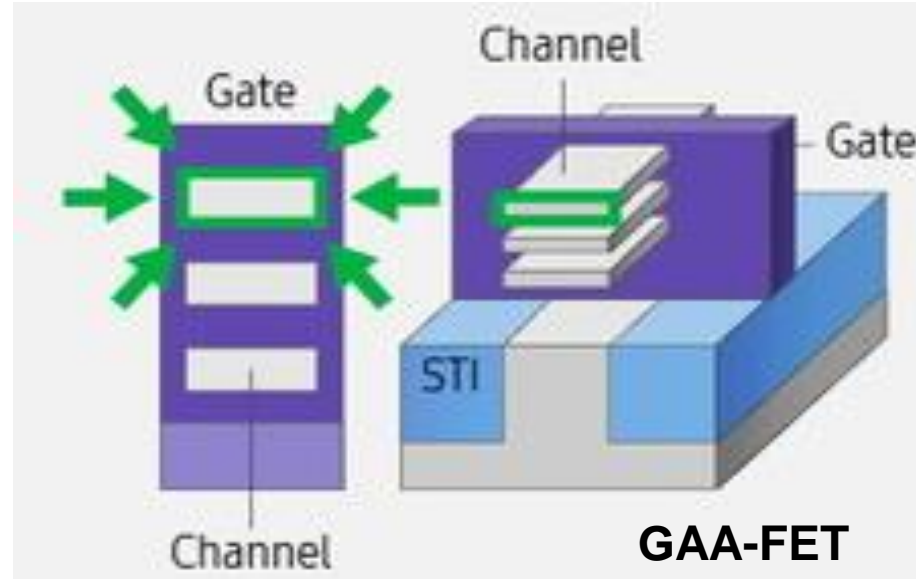
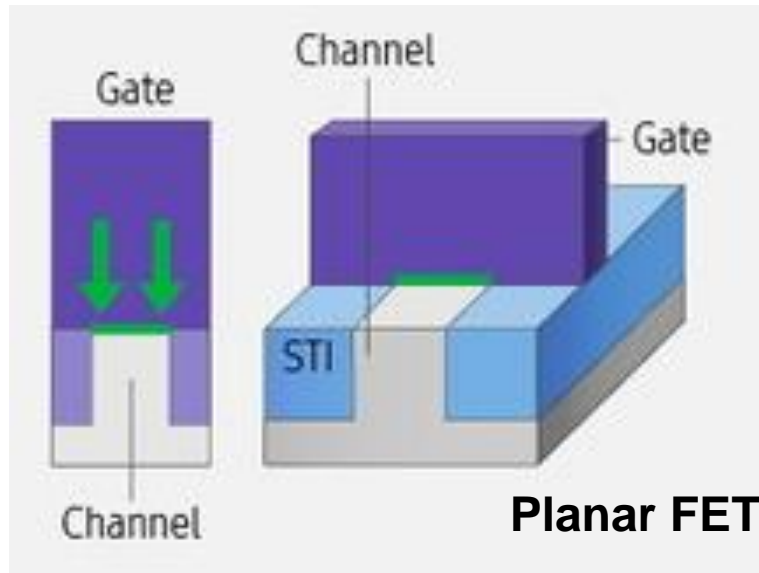
Fly-through of reconstructed volume from ptychography-laminography data collected from a 16 nm FinFET IC

# Evolution of Transistors

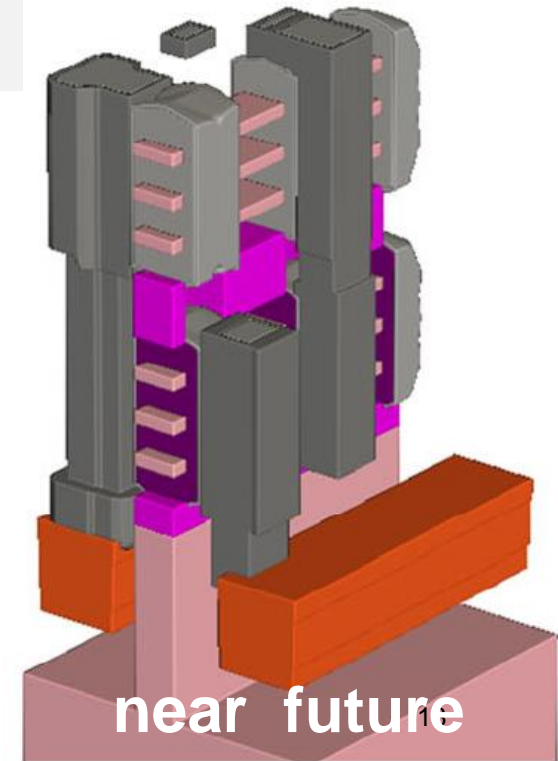




# Evolution of Transistors

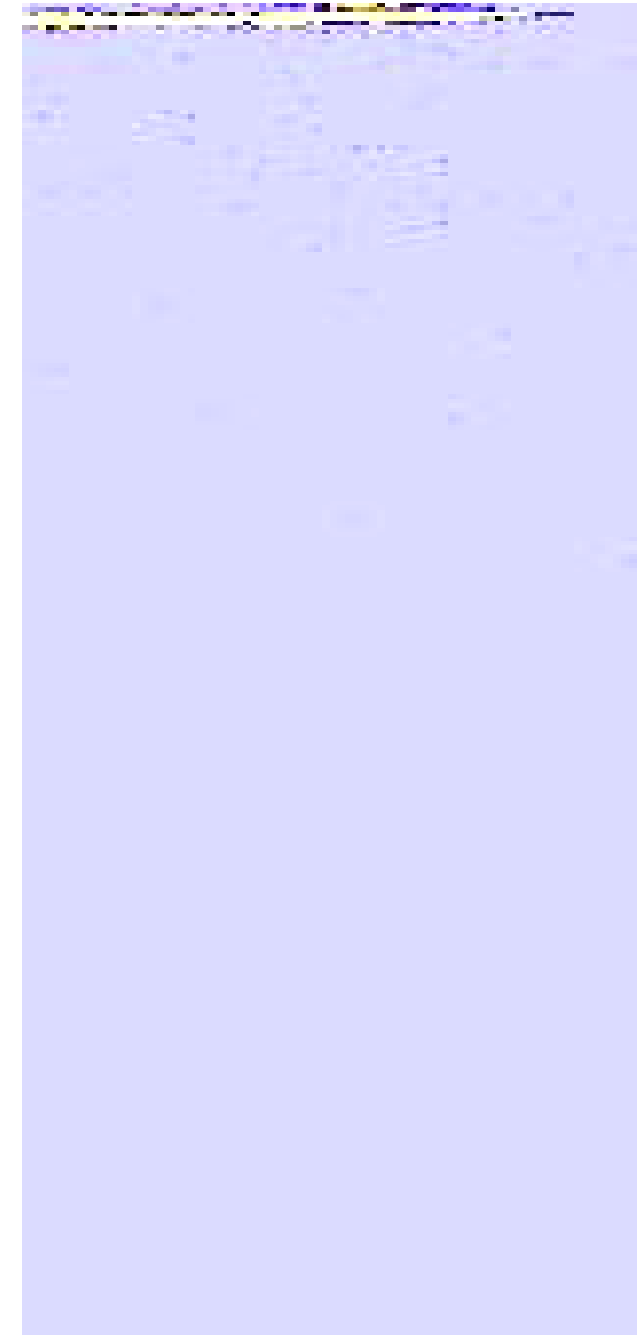
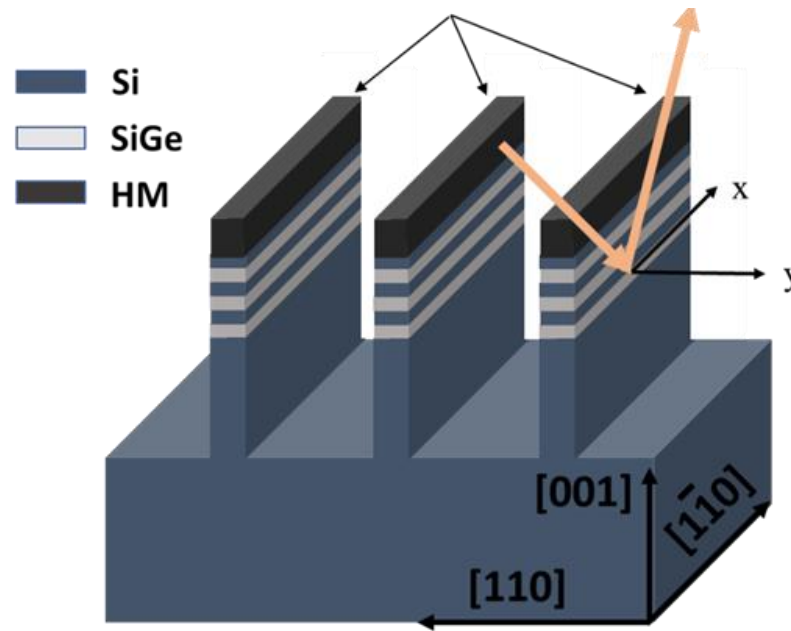
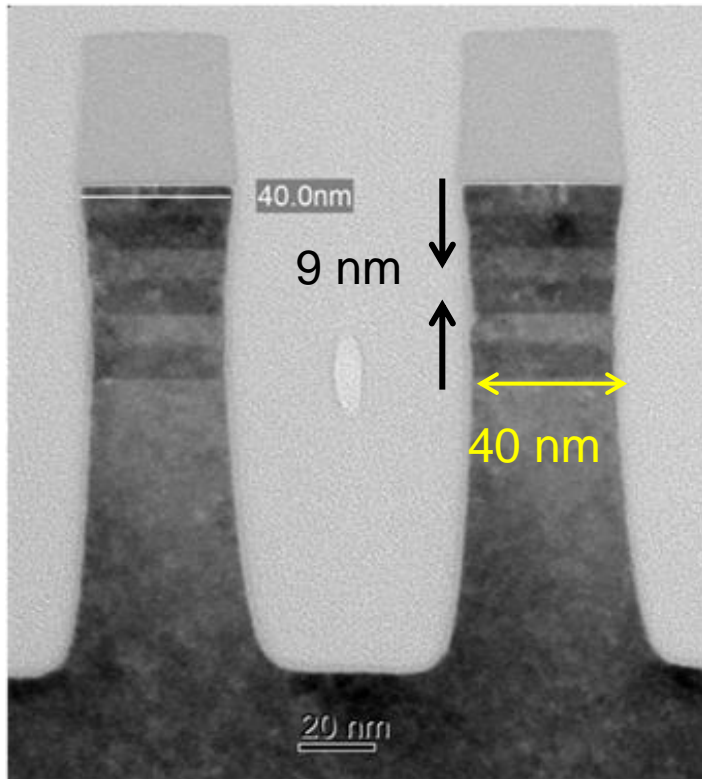


*Courtesy of  
C. Lavoie, IBM*

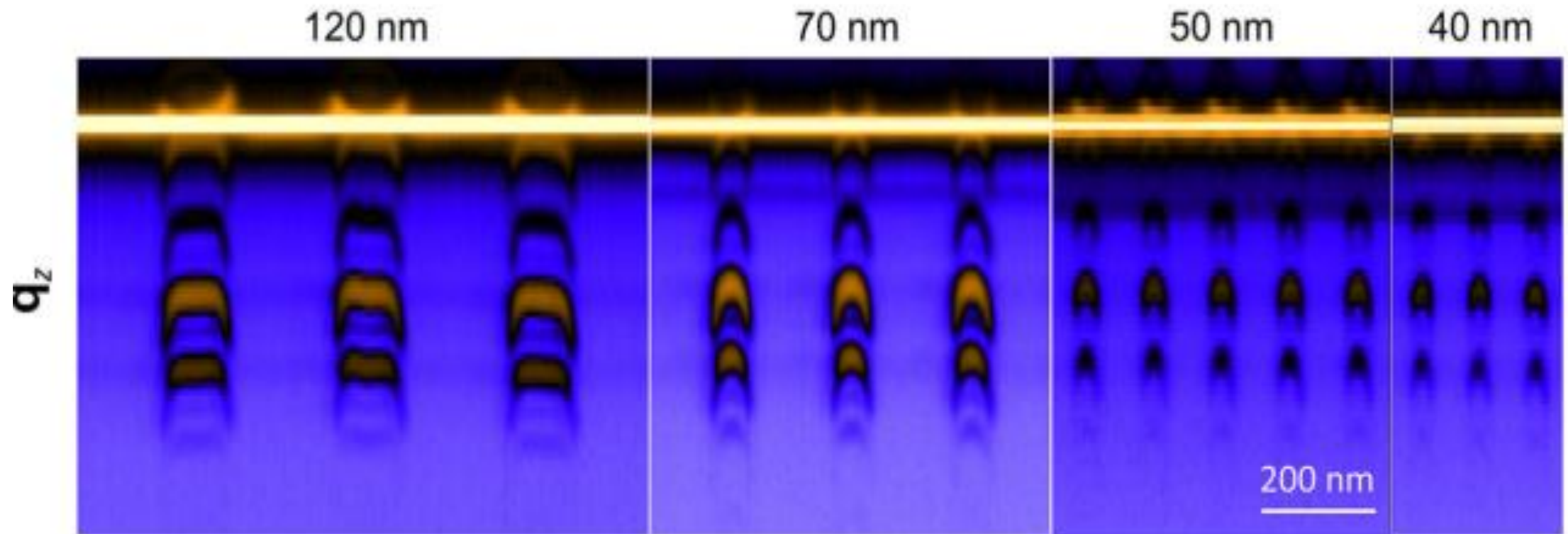


# Strain mapping at 10nm

IBM-NSLS-II collaboration



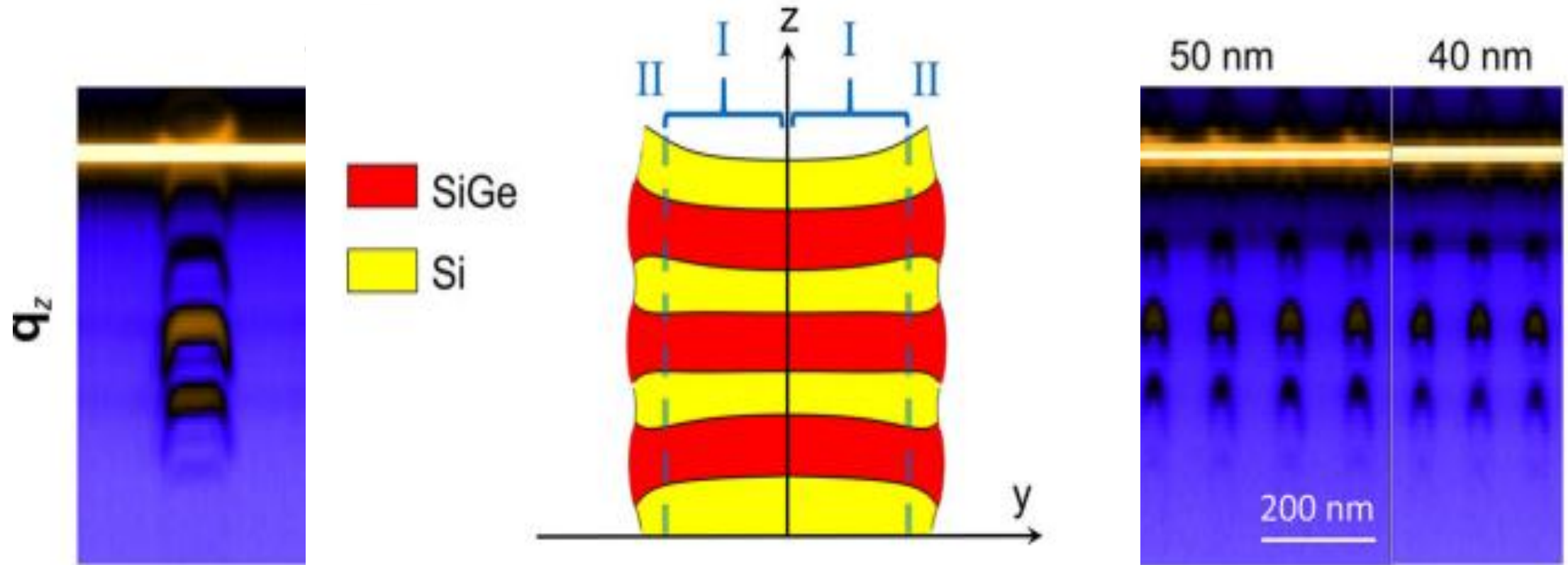
# Spatially-resolved Diffraction Pattern



*Murray et. al., Commun. Eng. 1 (2022)*



# Spatially-resolved Diffraction Pattern



*Murray et. al., Commun. Eng. 1 (2022)*

# Vision going forward





**Brookhaven™**  
National Laboratory

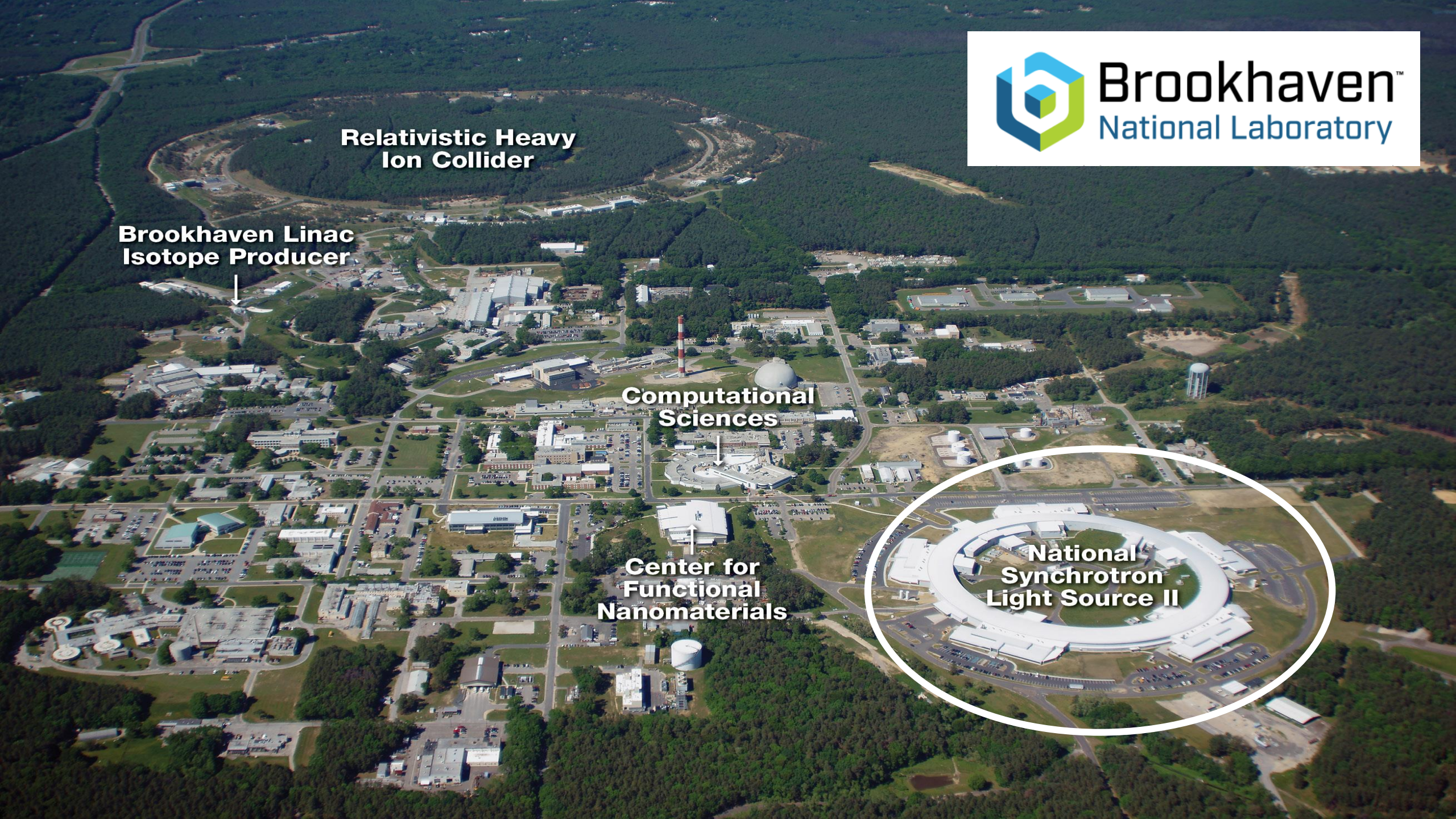
**Relativistic Heavy  
Ion Collider**

**Brookhaven Linac  
Isotope Producer**

**Computational  
Sciences**

**Center for  
Functional  
Nanomaterials**

**National  
Synchrotron  
Light Source II**







**Brookhaven™**  
National Laboratory

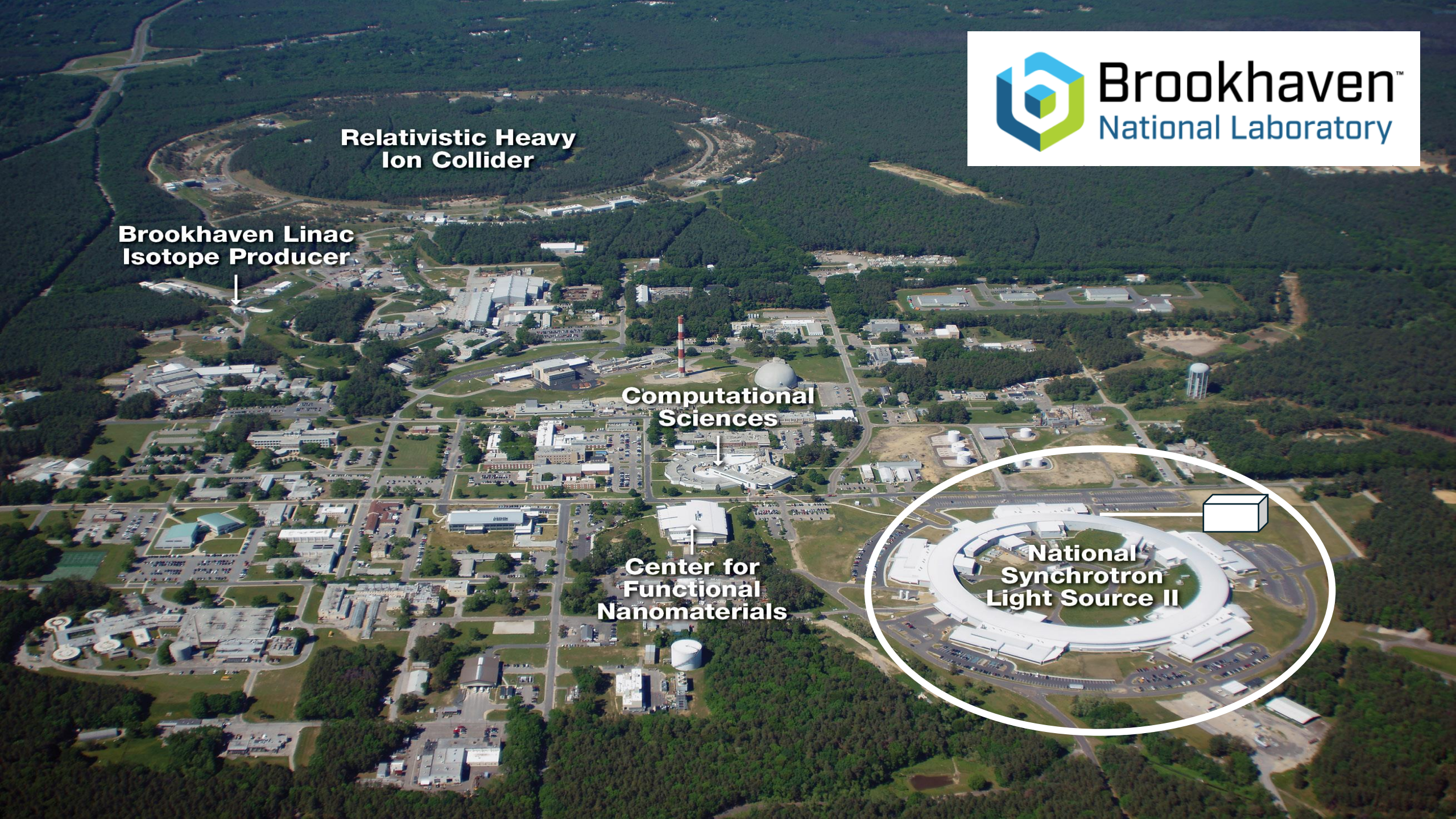
**Relativistic Heavy  
Ion Collider**

**Brookhaven Linac  
Isotope Producer**

**Computational  
Sciences**

**Center for  
Functional  
Nanomaterials**

**National  
Synchrotron  
Light Source II**





# Proposed new capabilities at BNL

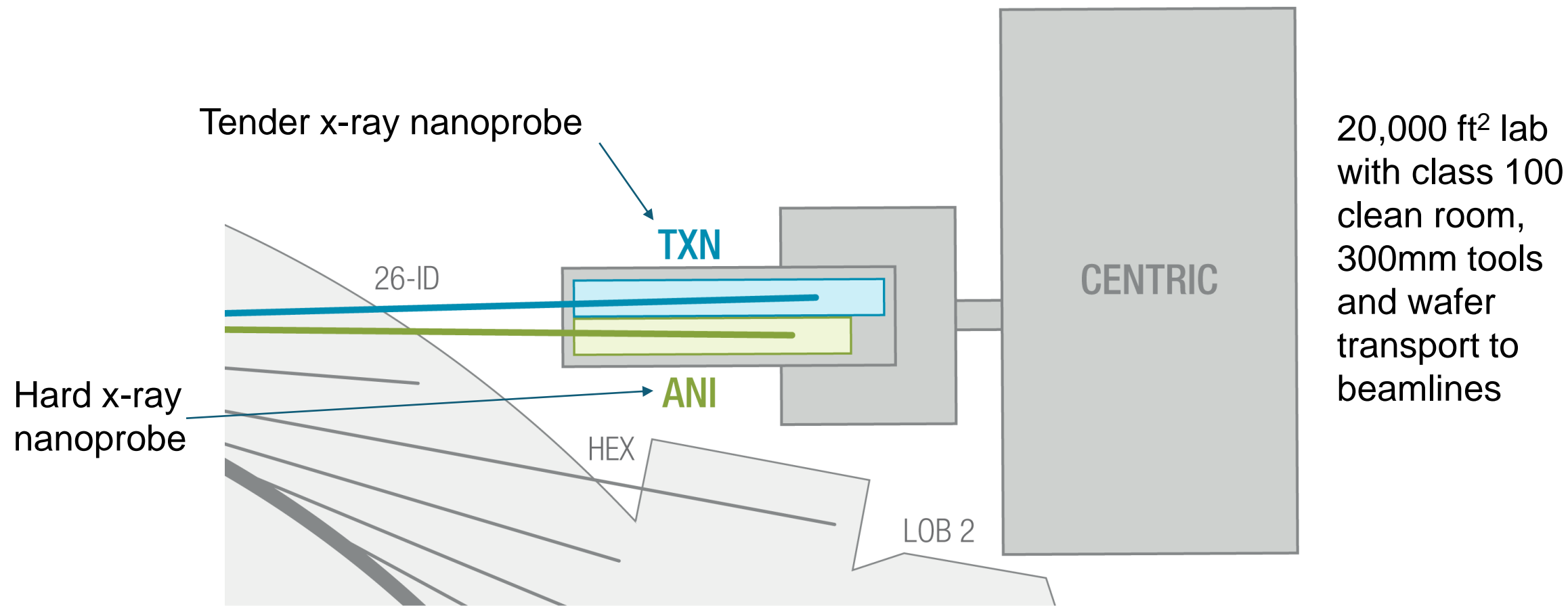


Figure not to scale

# Proposed new capabilities at BNL



Beamlines could be run as partnership between NIST and NYS to enable industrial access

Note: NIST already partner on 3 other beamlines at NSLS-II bringing additional capabilities

# Summary

- Microchips are vital to the US economy, National Security and our quality of life
- Current technology is coming to the end of what is possible.
- We need basic research to discover and perfect the solutions for next generation chips
- BNL working with NIST and NY State can play a crucial role in the Nation's competitiveness in this vital industry



# Conclusion

- BNL has a new management team in place:
  - Director, JoAnne Hewett,
  - Deputy for Science and Technology, John Hill
  - Deputy for Operations, Ann Emrick
- While maintaining BNL's current priorities (EIC!), we will be working on a new strategic plan to take the lab into the next decade
- With the science we can deliver and the challenges we can tackle, it promises to be BNL's most exciting decade yet!
- Looking forward to working with the CAC to enable this vision!