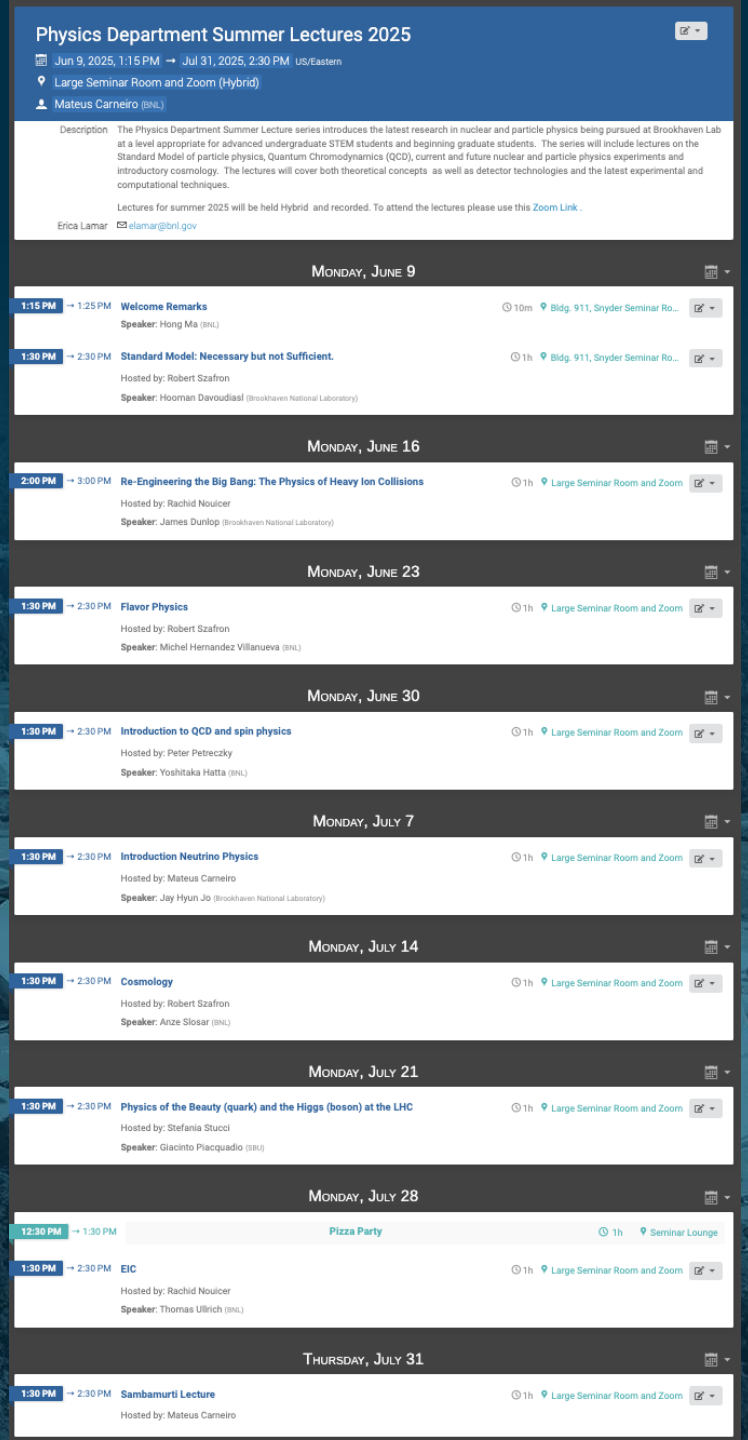
Welcome to BNL Physics Department Summer Lectures

Hong Ma

Chair, Physics Department

Brookhaven National Lab

June 9, 2025



Physics Department Summer Lectures 2025

Jun 9, 2025, 1:15 PM → Jul 31, 2025, 2:30 PM US/Eastern

Large Seminar Room and Zoom (Hybrid)

Mateus Carneiro (BNL)

Description: The Physics Department Summer Lecture series introduces the latest research in nuclear and particle physics being pursued at Brookhaven Lab at a level appropriate for advanced undergraduate STEM students and beginning graduate students. The series will include lectures on the Standard Model of particle physics, Quantum Chromodynamics (QCD), current and future nuclear and particle physics experiments and introductory cosmology. The lectures will cover both theoretical concepts as well as detector technologies and the latest experimental and computational techniques.

Lectures for summer 2025 will be held Hybrid and recorded. To attend the lectures please use this Zoom Link .

Erica Lamar elamar@bnl.gov

Monday, June 9

1:15 PM → 1:25 PM Welcome Remarks — 10m — Bldg. 911, Snyder Seminar Ro...
Speaker: Hong Ma (BNL)

1:30 PM → 2:30 PM Standard Model: Necessary but not Sufficient. — 1h — Bldg. 911, Snyder Seminar Ro...
Hosted by: Robert Szafron
Speaker: Hoornan Davoudiasl (Brookhaven National Laboratory)

Monday, June 16

2:00 PM → 3:00 PM Re-Engineering the Big Bang: The Physics of Heavy Ion Collisions — 1h — Large Seminar Room and Zoom
Hosted by: Rachid Nouicer
Speaker: James Dunlop (Brookhaven National Laboratory)

Monday, June 23

1:30 PM → 2:30 PM Flavor Physics — 1h — Large Seminar Room and Zoom
Hosted by: Robert Szafron
Speaker: Michel Hernandez Villanueva (BNL)

Monday, June 30

1:30 PM → 2:30 PM Introduction to QCD and spin physics — 1h — Large Seminar Room and Zoom
Hosted by: Peter Petreczky
Speaker: Yoshitaka Hatta (BNL)

Monday, July 7

1:30 PM → 2:30 PM Introduction Neutrino Physics — 1h — Large Seminar Room and Zoom
Hosted by: Mateus Carneiro
Speaker: Jay Hyun Jo (Brookhaven National Laboratory)

Monday, July 14

1:30 PM → 2:30 PM Cosmology — 1h — Large Seminar Room and Zoom
Hosted by: Robert Szafron
Speaker: Anze Slosar (BNL)

Monday, July 21

1:30 PM → 2:30 PM Physics of the Beauty (quark) and the Higgs (boson) at the LHC — 1h — Large Seminar Room and Zoom
Hosted by: Stefania Stucci
Speaker: Giacinto Piacquadio (SBU)

Monday, July 28

12:30 PM → 1:30 PM Pizza Party — 1h — Seminar Lounge

1:30 PM → 2:30 PM EIC — 1h — Large Seminar Room and Zoom
Hosted by: Rachid Nouicer
Speaker: Thomas Ullrich (BNL)

Thursday, July 31

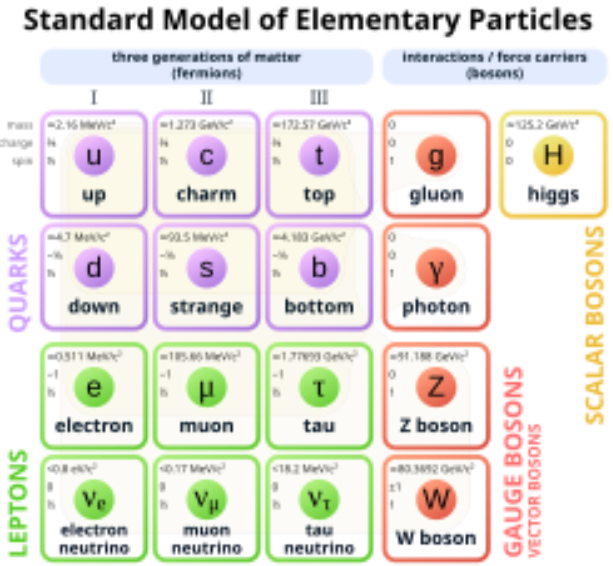
1:30 PM → 2:30 PM Sambamurti Lecture — 1h — Large Seminar Room and Zoom
Hosted by: Mateus Carneiro

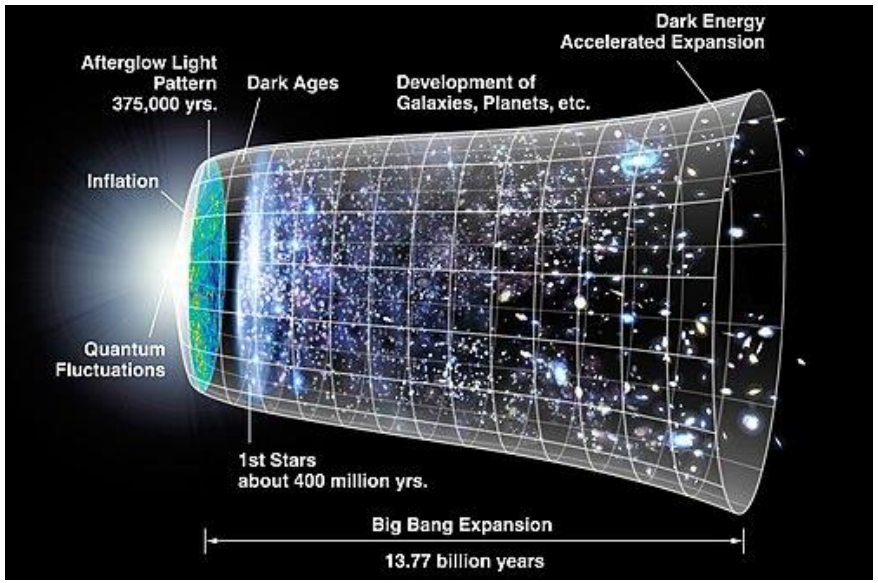
Nuclear and Particle Physics at BNL

https://www.bnl.gov/npp/

Exploring the building blocks of matter and the nature of space and time

Vibrant programs in experimental and theoretical research in nuclear and high-energy physics, accelerator design, and isotope production. Full mission statement



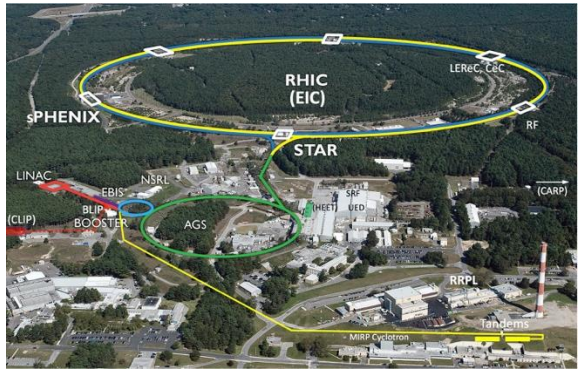


Brookhaven National Laboratory

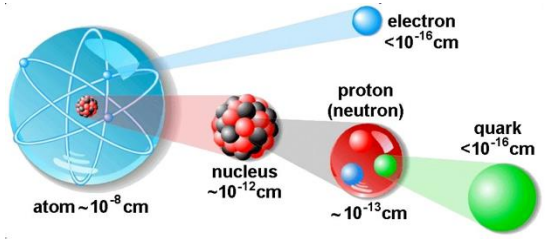
Mission of NPP

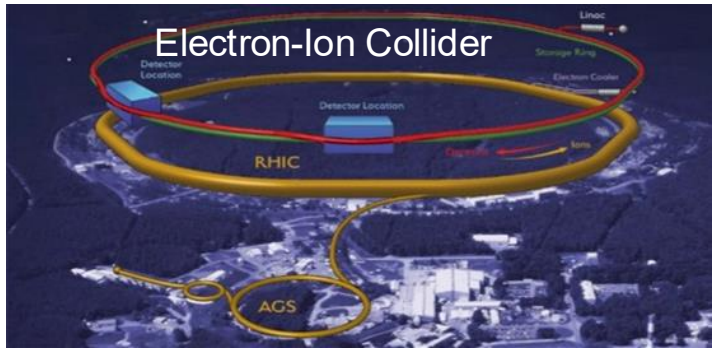
Our mission is to lead and support discovery-based, innovation-driven research at the frontiers of the subatomic world. We are world-leading in nuclear physics research, building and operating accelerator-based user facilities that serve international scientific communities. We also play a leading role in global particle physics programs that push the limits of precision and expand our understanding of the cosmos. Our pursuit of this fundamental and discovery research yields scientific and technological breakthroughs, and also applications that benefit society—such as radioisotopes used to support industrial, medical and national security needs.

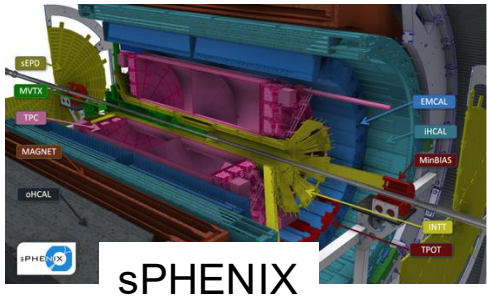
Frontier Science Programs in nuclear and particle physics, for decades to come.



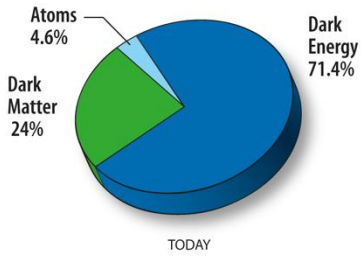
To understand sub-atomic world deeper and deeper

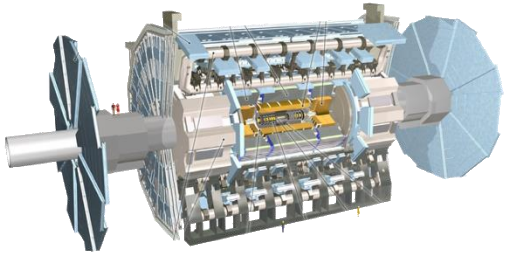




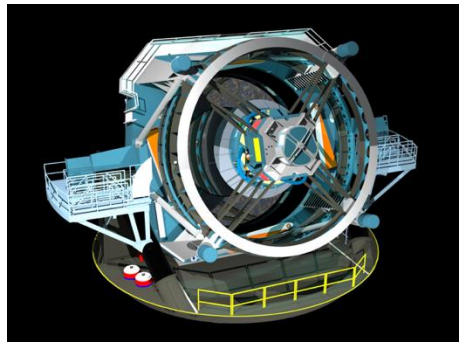


sPHENIX

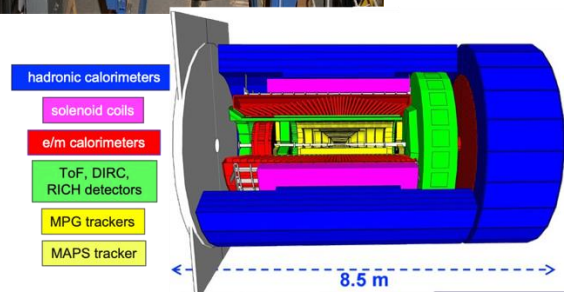




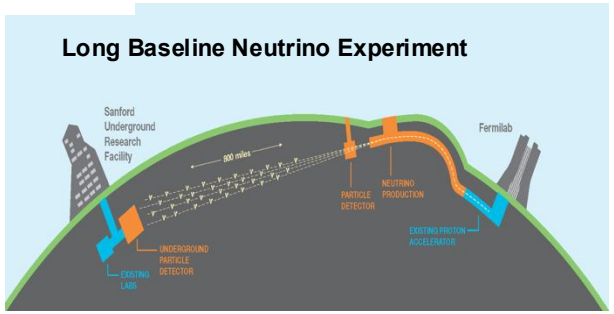
ATLAS @ LHC



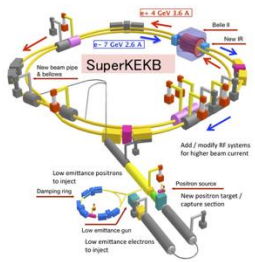
Rubin Observatory

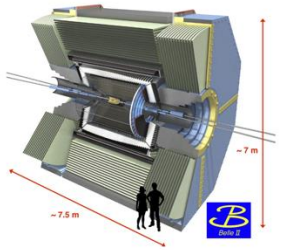


ePIC

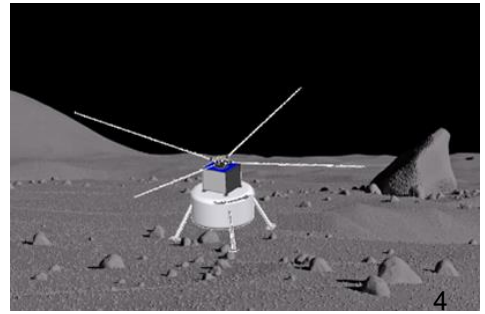


DUNE at FNAL





Belle II at SuperKEKB



LuSEE-Night mission

Brookhaven National Laboratory

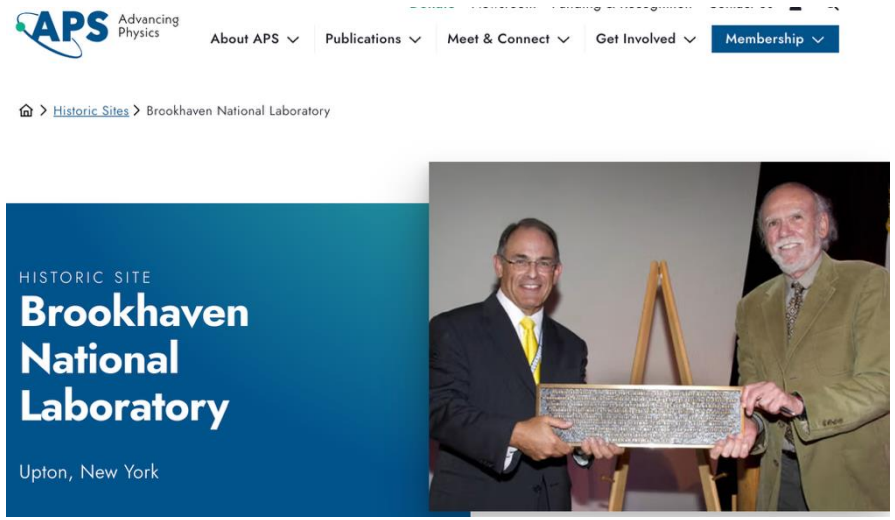
High-energy and Nuclear Theory groups; Software and Computing groups
RIKEN-BNL Research Center (RBRC); Center for Frontiers in Nuclear Science (CFNS)

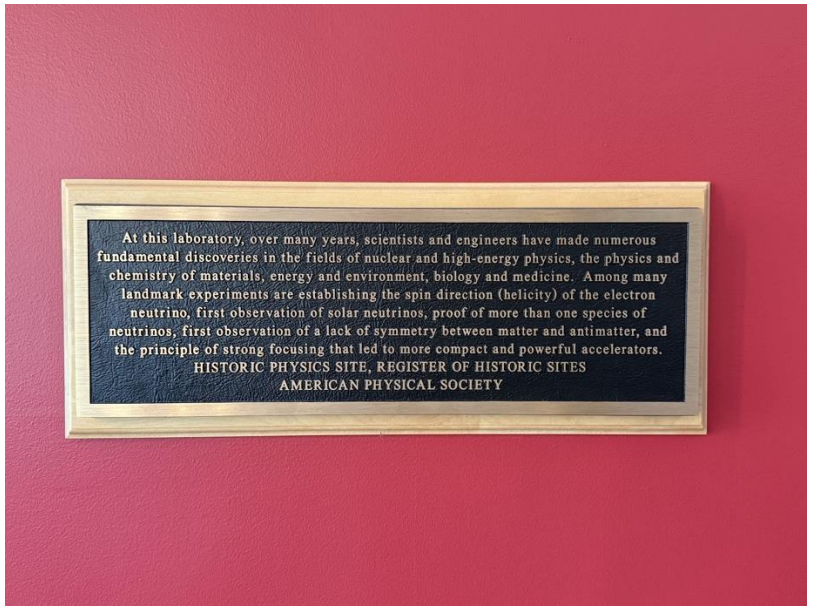
BNL as an APS Historical Site (2011)

At this laboratory, over many years, scientists and engineers have made numerous fundamental discoveries in the fields of nuclear and high energy physics, the physics and chemistry of materials, energy and environment, biology and medicine. Among many landmark experiments are establishing the **spin direction (helicity) of the electron neutrino, first observation of solar neutrinos, proof of more than one species of neutrinos, first observation of a lack of symmetry between matter and antimatter**, and the principle of strong focusing that led to more compact and powerful accelerators.

Other significant achievements by BNL scientists:

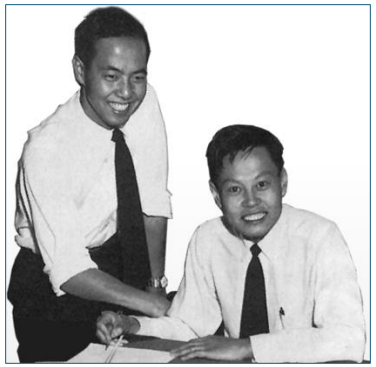
- The discovery of the **Omega Minus Particle** in 1964;
- The **co-discovery of the J/psi**, a charm-anticharm vector meson, that required a fourth quark.





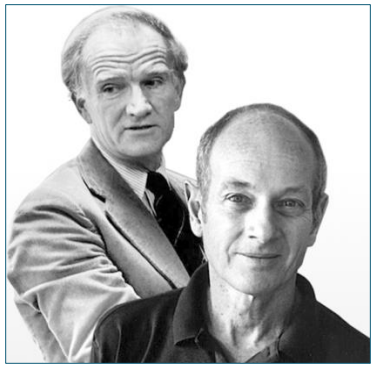
Brookhaven National Laboratory

Nobel Prizes in Physics for discoveries at BNL



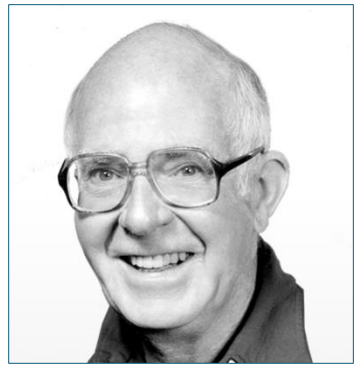
1957 Physics: Lee (Columbia) and Yang (BNL) for parity violation

1976 Physics: Ting (MIT) for discovery of the J/Psi particle



1980 Physics: Cronin and Fitch(Princeton) for CP Violation

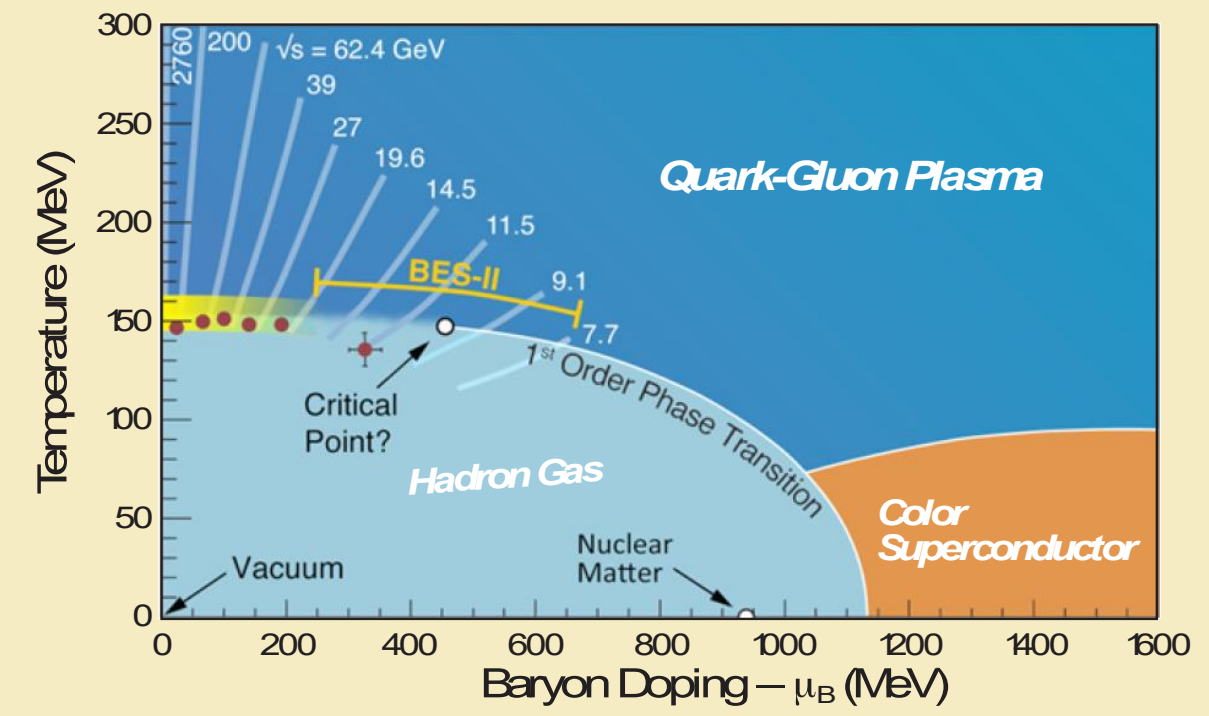
1988 Physics: Lederman, Schwartz, Steinberger (Columbia) for discovery of the muon-neutrino

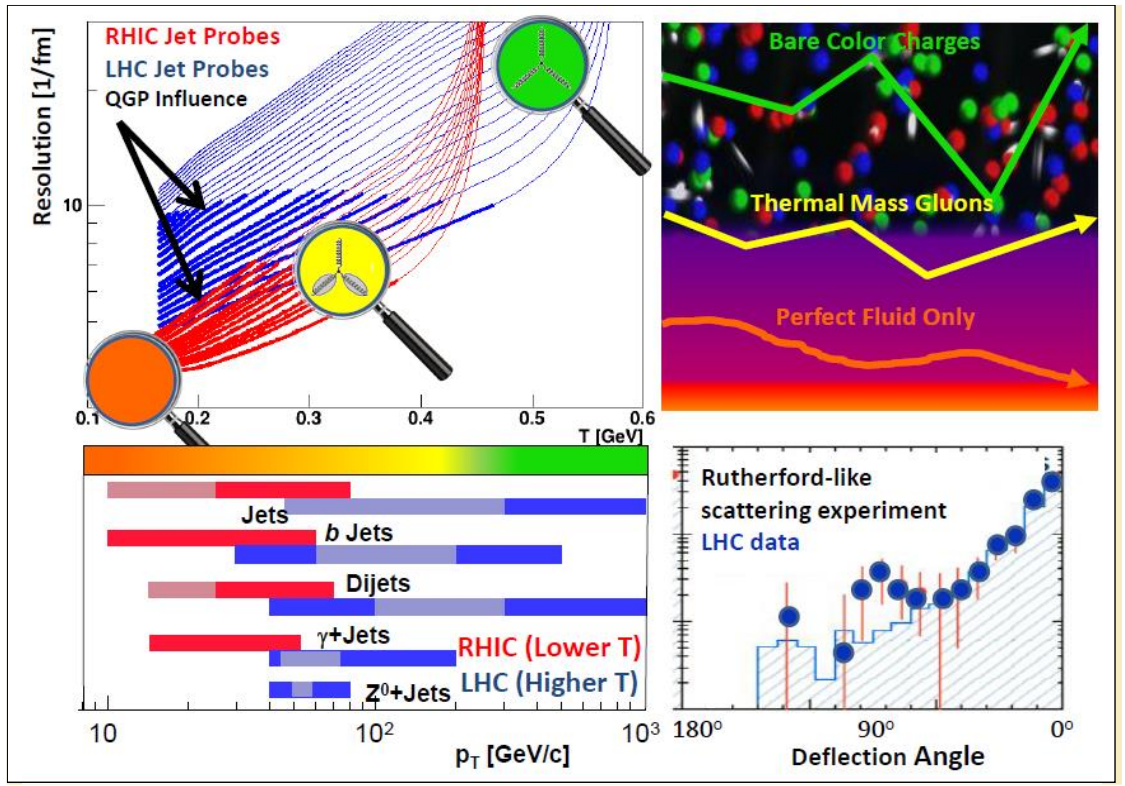


2002 Physics: Davis (BNL) for detection of solar neutrino and its deficit

Completing the RHIC Mission

- Study of the properties of Quark Gluon Plasma and its phase transition
- Understanding of the origin of proton spin





Analysis of Runs 2019-2021 from STAR Exploring the phase diagram of QCD matter; polarized proton run in 2022

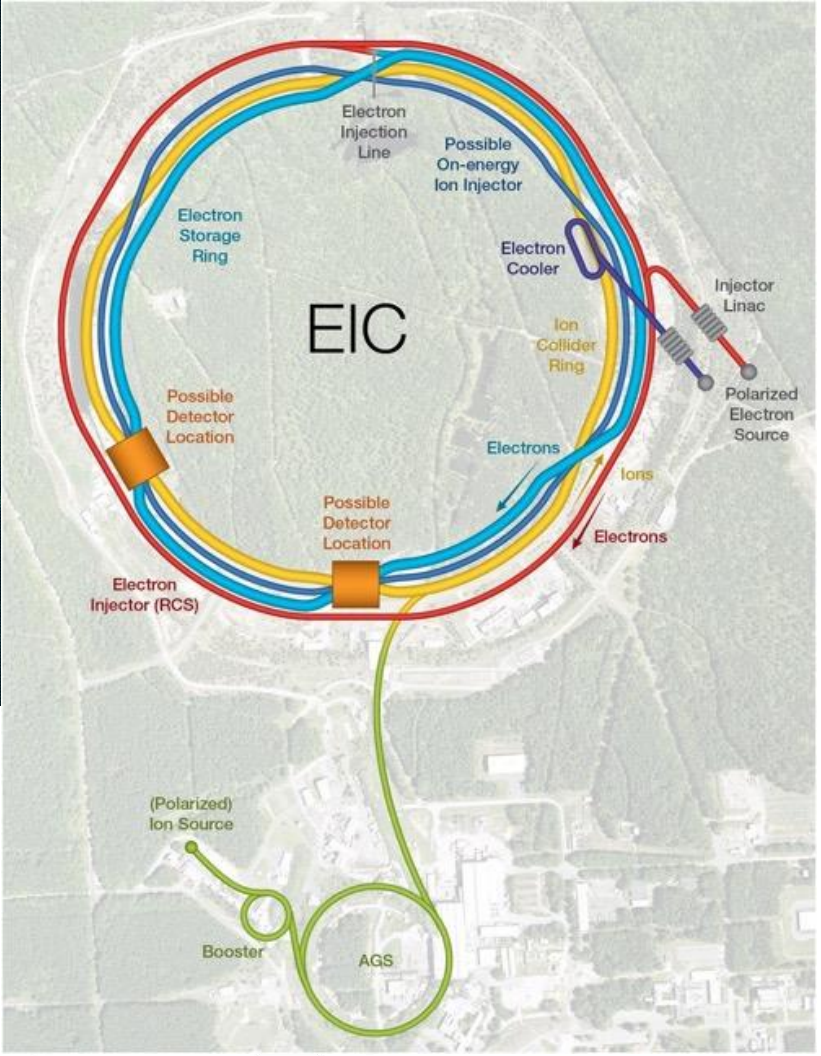
Runs 2023-2025 with sPHENIX and STAR: how does the perfect fluid emerge from quarks and gluons?

https://www.bnl.gov/eic/

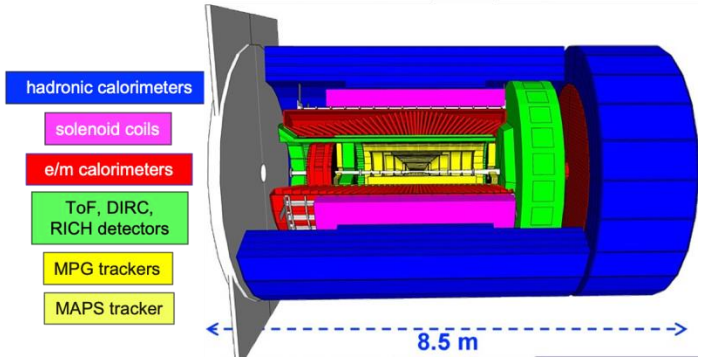
The Electron-Ion Collider

A machine that will unlock the secrets of the strongest force in Nature

- Discovery machine will allow scientists to look inside protons and neutrons and unlock mysteries of the strong force that binds nature's building blocks: quarks and gluons
- Research and development for the EIC will lead to advanced technology and useful applications
- The EIC is being built through a partnership with DOE, Brookhaven, and Thomas Jefferson National Accelerator Facility with additional support from New York State
- The EIC also benefits from participation among international collaborators



- How does the **mass** of the nucleon arise?
- How does the **spin** of the nucleon arise?
- What are the emergent properties of dense systems of gluons?



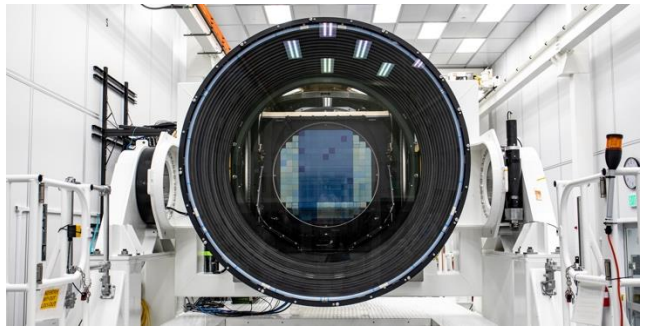
Brookhaven National Laboratory

ePIC

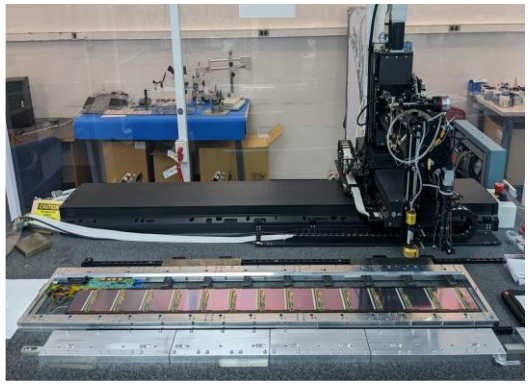
High Energy Physics Program in Physics Department

- **Energy Frontier**
  - Hosting project for $300M HL-LHC ATLAS upgrade
  - Building magnets for the HL-LHC
  - Developing HL-LHC computing and software
- **Intensity Frontier**
  - Contributing to DUNE experiment
    - Leading DUNE far detector Module 2 activities
  - Belle II detector operations during Run II
- **Cosmic Frontier**
  - Getting ready to analyze Rubin Observatory data
  - Building LuSEE-Night mission to the far side of the moon
- **Leading Technologies Developments for Particle Physics**
  - Computing and software
  - Detectors and electronics
  - AI/ML and Quantum Information Science
- **Actively participating in developing long term future**
  - Higgs Factory, DUNE Phase 2 upgrade, Muon collider

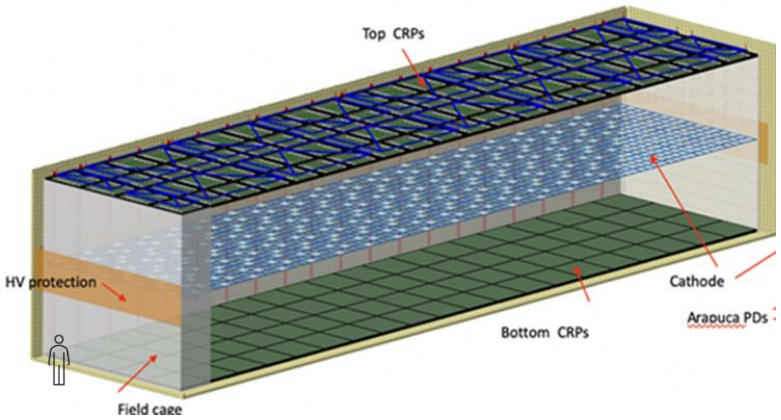
LSST Camera



ATLAS silicon assembly at BNL

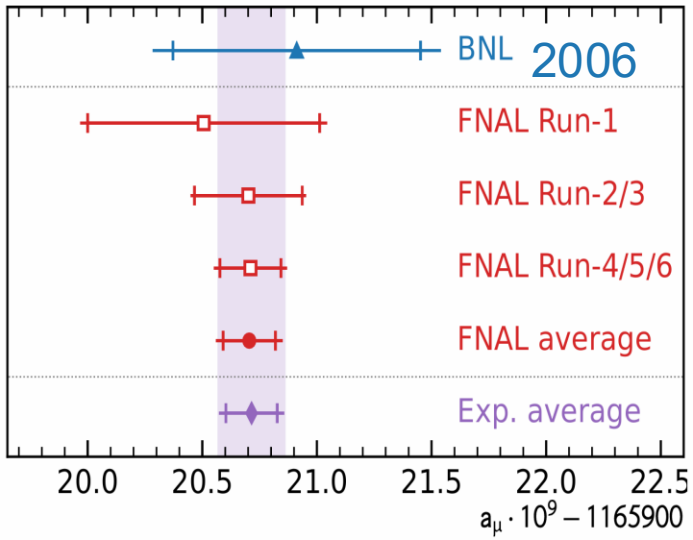


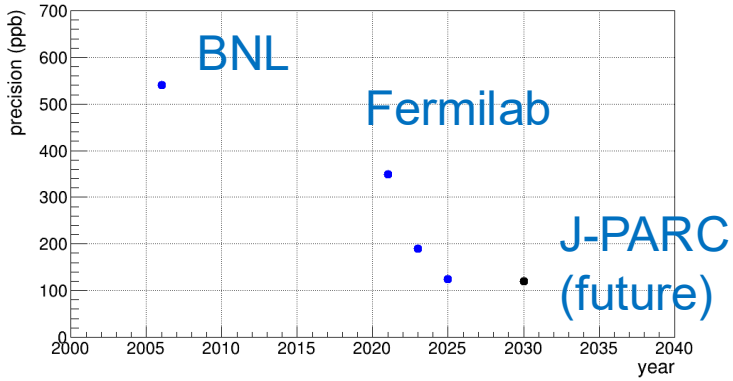
DUNE Module 2 design



The final result of Fermilab muon g-2 experiment

A precision measurement of muon anomalous magnetic moment to a precision of 127 parts per billion





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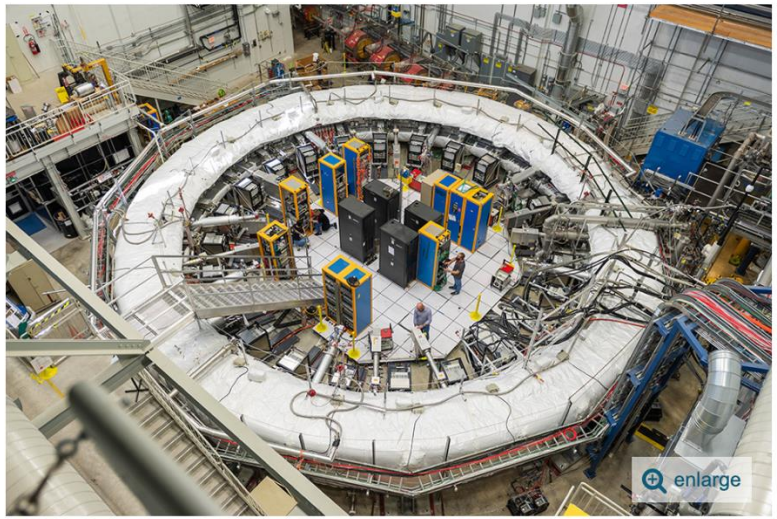
Contact: Peter Genzer, (631) 344-3174 share:

Muon g-2 Announces Most Precise Measurement of the Magnetic Anomaly of the Muon

June 3, 2025



The Muon g-2 experiment at Fermi National Accelerator Laboratory. (Ryan Postel/Fermilab)

The New York Times

Muon Experiment Was 'Hugely Successful' but Clarified Little

The deviant behavior of a subatomic particle might point to undiscovered forms of matter and energy in the universe. Or it might not.

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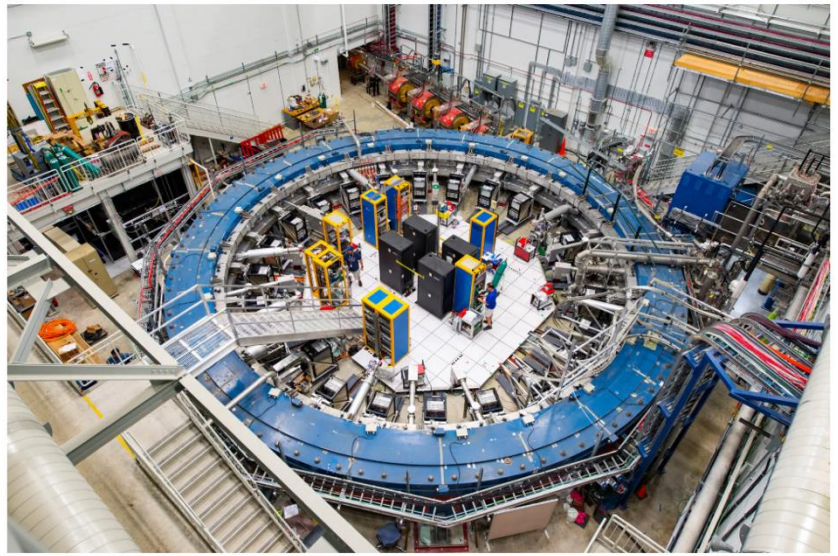


The Muon g-2 ring in its detector hall at Fermilab in Batavia, Ill., in 2017. Reidar Hahn/Fermilab

Rubin Observatory First Look Watch Party, June 23

Coming June 23, 2025: First Look at the cosmos with NSF–DOE Vera C. Rubin Observatory

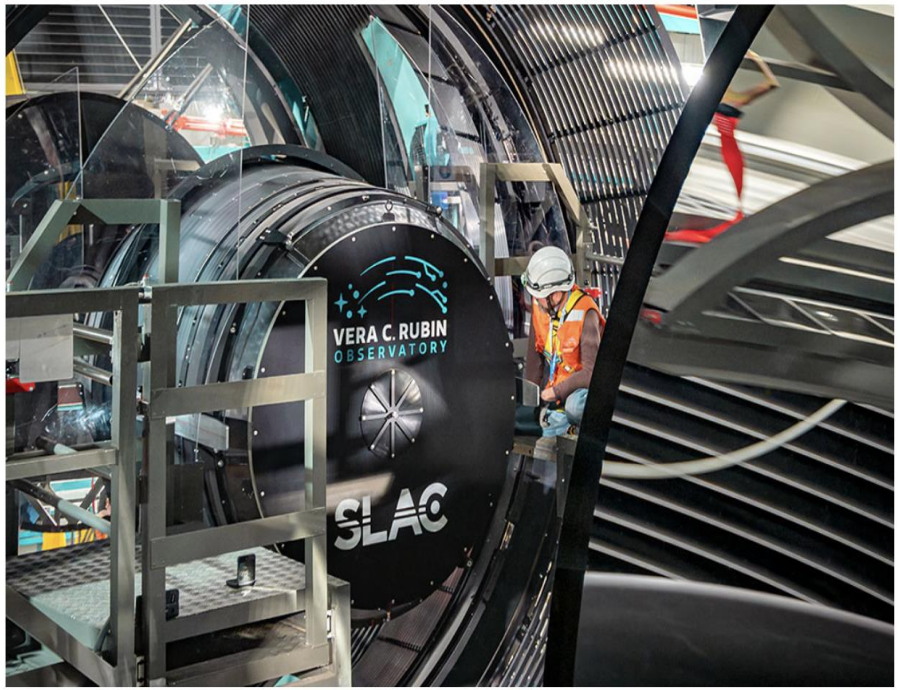
Get ready to join us virtually around the world on **June 23, 2025 at 11:00 a.m. US EDT** as we unveil the first spectacular images from NSF–DOE Vera C. Rubin Observatory! This First Look event will be live streamed via Youtube in English and in Spanish — links will be made available here and via social media. Join us to celebrate the start of a new era in astronomy and astrophysics with the world's newest and most powerful survey telescope.

Over the next ten years, Rubin Observatory will create the ultimate movie of the night sky using the largest camera ever built — repeatedly scanning the sky to create an ultra-wide, ultra-high-definition time-lapse record of our Universe.

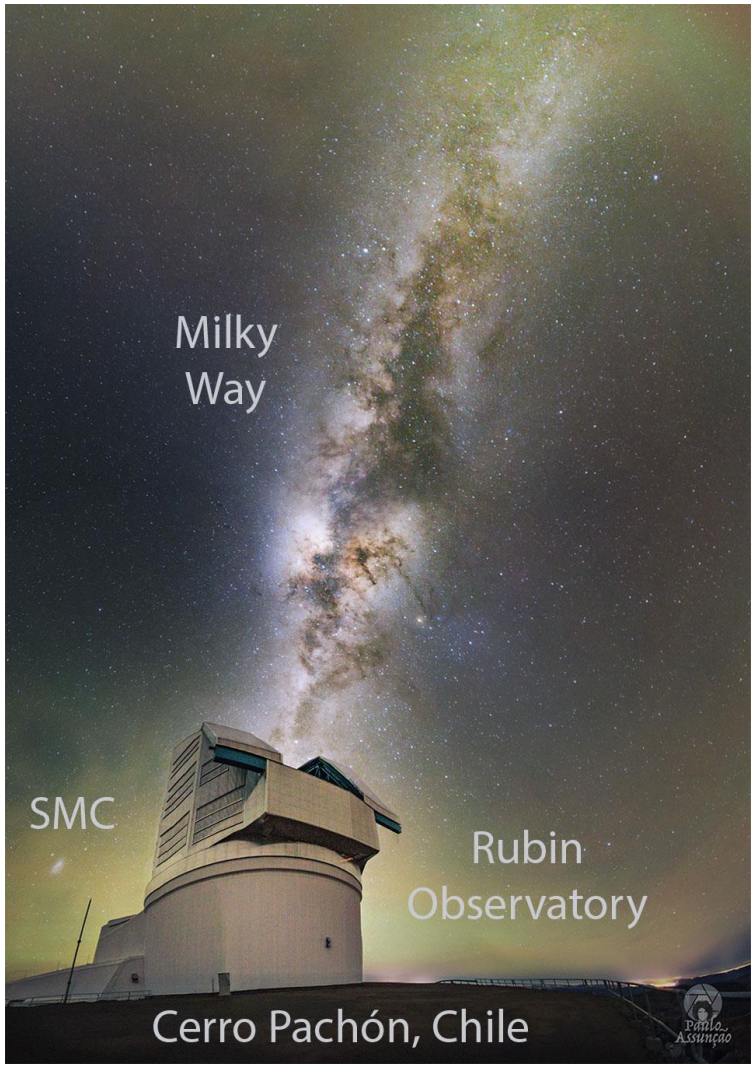
NSF-DOE Vera C. Rubin Observatory Installs LSST Camera on Telescope

Using the largest digital camera in the world, Rubin Observatory will soon be ready to capture more data than any other observatory in history

March 18, 2025



The Legacy Survey of Space and Time Camera installed at the NSF-DOE Vera C. Rubin Observatory in Chile. Credit: NSF-DOE Rubin Observatory/B. Quint



nature

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NEWS AND VIEWS | 06 November 2024

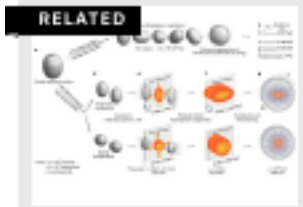
Rare snapshots of a kiwi-shaped atomic nucleus

Smashing uranium-238 ions together proves to be a reliable way of imaging their nuclei. High-energy collision experiments reveal nuclear shapes that are strongly elongated and have no symmetry around their longest axis.

By Magda Zielińska & Paul E. Garrett

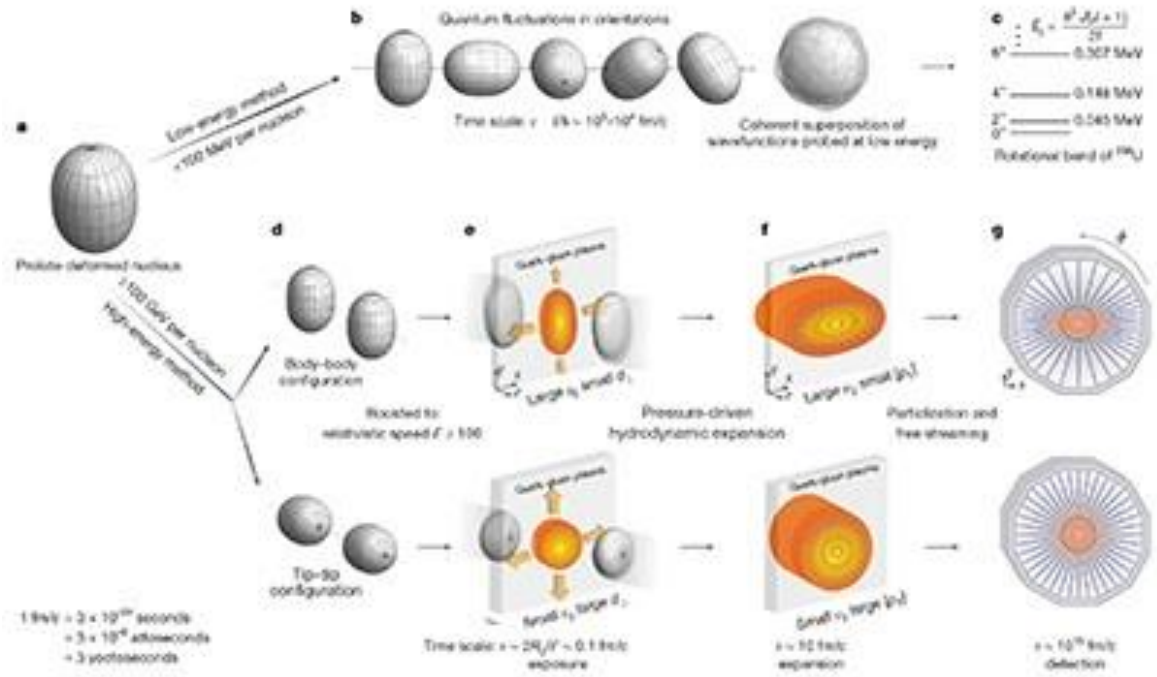
If the average atomic nucleus were as big as a basketball, an atom would have a diameter of around 5 or 6 kilometres. It might therefore seem reasonable to think of the nucleus as a tiny, point-like ball. Further investigation, however, reveals that nuclei take on a range of shapes, with ellipsoids being the most common. Information about nuclear shape is typically obtained by shooting a beam of particles onto a fixed target at velocities of a few per cent of the speed of light[1]. Writing in *Nature*, the STAR Collaboration[2] reports that detailed imaging of nuclear shapes is also possible using data collected when heavy ions collide at velocities that approach the speed of light.

RELATED

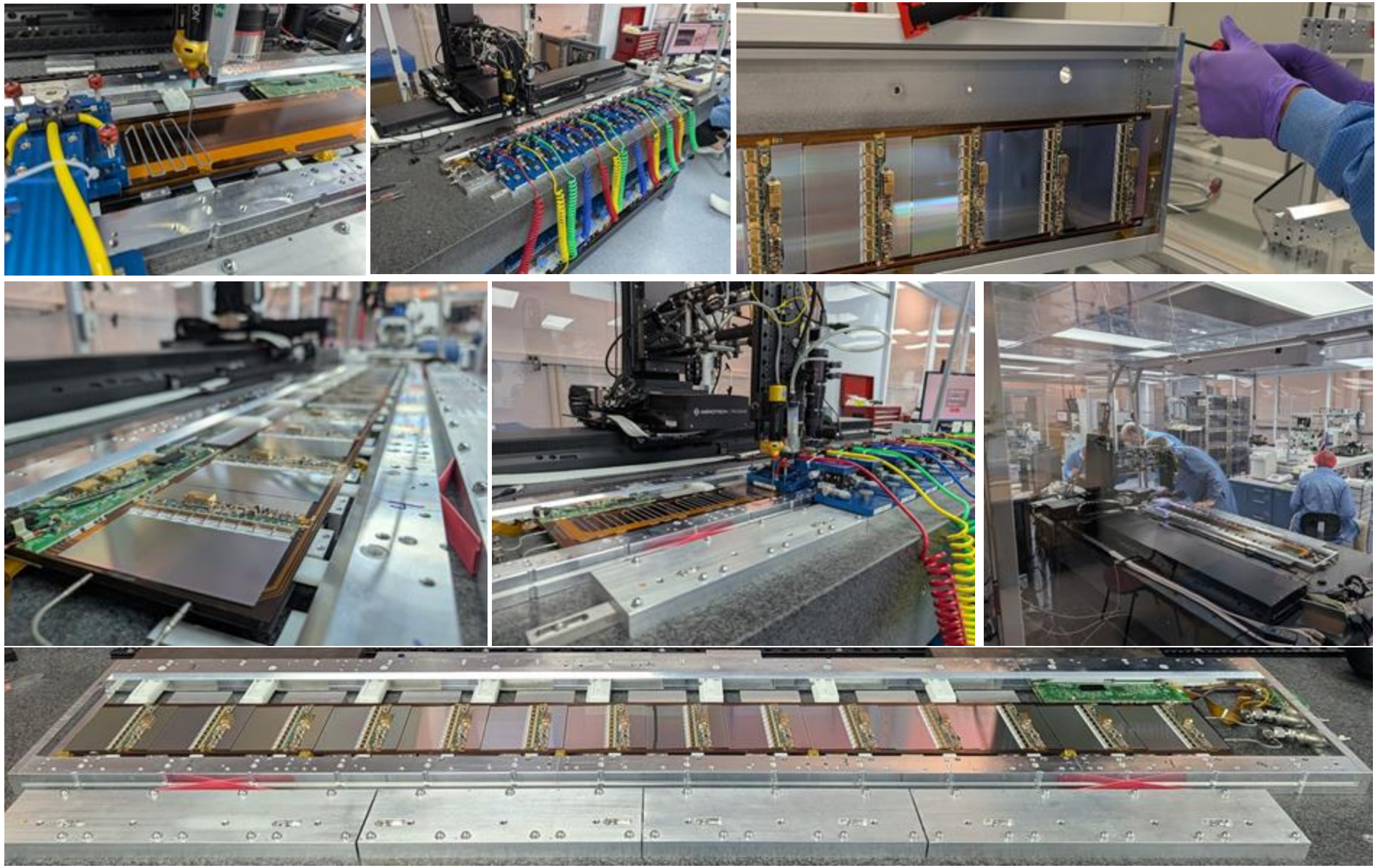


Read the paper: Imaging shapes of atomic nuclei in high-energy nuclear collisions

Research into nuclear structure usually involves deducing the shape of a nucleus by exciting it to a higher energy state (in a collision with a target, for example), and then comparing its energy — and the rate at which the excited nucleus decays — with values predicted using theoretical models. The shape can also be inferred in a more direct way by measuring a quantity known as the electric quadrupole moment of the nucleus, which is related to the distribution of protons (and therefore of charge) in the nucleus. In nuclei that are spherical, this measure is zero, but in those that are elongated, the moment is non-zero.



the STAR Collaboration reports that detailed imaging of nuclear shapes is also possible using data collected when heavy ions collide at velocities that approach the speed of light.



Completion of the first stave of silicon strip detector for the ATLAS HL-LHC Upgrade in May 2025
195 staves to go in the next 2-3 years!

Training the next generation scientists

Summer internship provides great opportunities for students to gain experience in working in a research lab and in large facilities

Summer lecture series introduces the latest research in nuclear and particle physics being pursued at Brookhaven Lab at a level appropriate for advanced undergraduate STEM students and beginning graduate students.

Enjoy the summer at BNL!

Many thanks to the lecture committee:
Peter Petreczky, Stefania Stucci, Mateus Carneiro (Chair), Rachid Nouicer, Robert Szafron