

Purpose

To study the fundamental properties of matter from elementary atomic particles to the evolution of the universe

Sponsor

U.S. Department of Energy's Office of Nuclear Physics

Replacement Cost

\$2 billion

Operating Costs

Over \$150 million per year

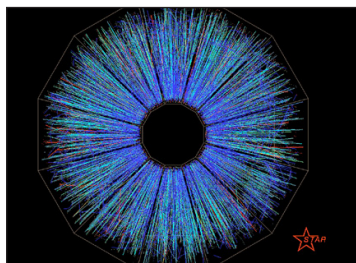
Features

- Two crisscrossing rings in a tunnel
- 2.4 miles in circumference
- 1,740 superconducting magnets
- Two detectors: PHENIX and STAR (BRAHMS and PHOBOS are no longer operating).

Users

- Over 1,000 per year from national and international laboratories, universities, and other research institutions.
- Over 550 collaborators each from STAR and PHENIX continue data taking, analysis, and detector upgrades to enhance capabilities.
 - Over 50 collaborators each from PHOBOS and BRAHMS continue analyzing data taken in 2006 and earlier.

www.bnl.gov/rhic



Particle tracks from a gold-gold collision at RHIC

RHIC: Dazzling Discoveries, Bright Future

Research at RHIC is a compelling, ongoing exploration of the fundamental properties of matter and the infant universe. By looking back to a time before protons and neutrons existed, we can study nature's strongest force — which holds everything from those fundamental particles to stars, planets, and people together — and delve into mysteries such as why the stuff around us even exists and how the universe evolved. This endeavor:

- **Captivates worldwide attention** and ignites public imagination
- **Draws researchers** from around the globe
- **Showcases U.S. leadership** in science
- **Inspires and trains** next-generation scientists and innovators
- **Provides cutting-edge technological advances** and expertise for fields from medicine to national security

Compelling discoveries

- First facility to clearly see the transition to quark-gluon matter
- “Perfect” liquid nature of the early universe, markedly different from the anticipated ideal gas
- Heaviest antimatter nucleus ever detected, likely to stand for foreseeable future
- “Bubbles” in which matter violates fundamental symmetries
- Temperatures reaching ~ 4 trillion degrees Celsius, substantially above the predicted melting temperature of neutrons and protons
- First indication of gluon saturation
- “Missing” proton spin not found among abundant gluons
- Unanticipated intellectual connections to other forefront science, including String Theory, ultra-cold atomic gases, and matter-antimatter imbalance of the infant universe



Scientists from around the world collaborate on research at RHIC

Vibrant future

Rate of discovery increasing due to cost-effective, ongoing upgrades

- 10-fold increase in collision rates achieved by exploiting accelerator technology breakthroughs made at RHIC, for a total cost of ~\$10M (saving ~\$100M vis-à-vis originally anticipated technology)
- Ion source upgrade (EBIS) expands range of ions available and enhances cost-effectiveness of operations
- Ongoing incremental detector upgrades greatly improve precision and sensitivity to rare processes

Future research directions enabled by upgrades and versatility

- Quantitative characterization of the early-universe matter
- Confirmation/refutation of symmetry-violating bubble prediction
- Search for a unique critical point (“continental divide”) at which quark matter coalesces, or freezes out, to form protons, neutrons, and all other ordinary matter
- How does the force between quarks change inside dense quark-gluon matter

Scientifically compelling path to long-range future (eRHIC) is fueled by additional accelerator science breakthroughs being pursued at RHIC

Continued on p. 2

RHIC: Dazzling Discoveries, Bright Future (continued)

Strong productivity

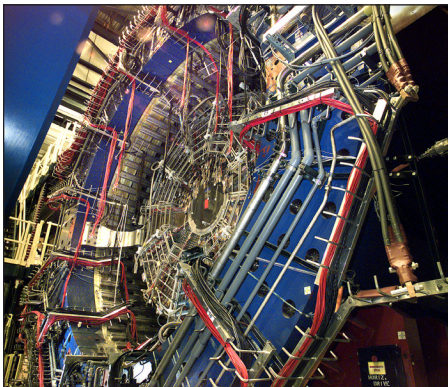
- > 300 refereed papers with > 20,000 citations
- > 200 Ph.D.s in first 10 years, hundreds more in the pipeline

Internationally competitive

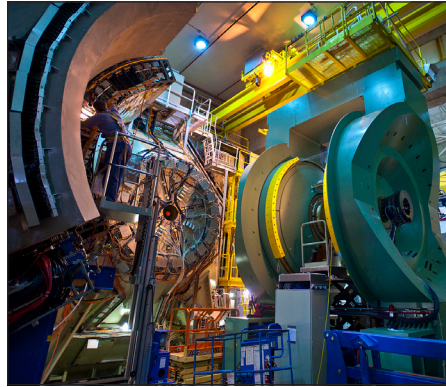
- Hits the “sweet spot” for detailed study of matter at the threshold of the universe due to extensive energy and ion species flexibility
- Dedicated primarily to heavy ion collisions (unlike LHC, where focus is high-energy physics)
- World’s only spin-polarized proton collider
- Soon to be only operating collider facility in the U.S.
- Major foreign investments, especially from Japan
- More than 1000 international collaborators

Benefits beyond physics

- Medical radioisotope production (Sr-82 for myocardial PET scans) a pre-injector accelerator; active R&D on new isotopes, e.g., Fe-52 for combined PET/MRI imaging



The STAR Detector at RHIC



The PHENIX Detector at RHIC

- RHIC Booster synchrotron used to study effects of space radiation, with strong NASA support
- Major accelerator technology breakthroughs: high-energy polarized beams; stochastic cooling of bunched beams; use of high-temperature superconducting magnets in accelerator systems
- CRADA for next-generation particle beam cancer therapy technology
- R&D for superconducting magnet energy storage (ARPA-E funding)
- R&D on accelerator technology with possible defense applications (ONR funding), in addition to relevance for eRHIC
- Superconducting RF developments relevant to potential high-power drivers for accelerator-driven sub-critical nuclear reactors
- Supports ~750 BNL staff (including indirects) and > 1000 international scientific users

For more information about RHIC, go to www.bnl.gov/rhic.

BROOKHAVEN
NATIONAL LABORATORY