FACTS

The Relativistic Heavy Ion Collider

BROOKHAVEN NATIONAL LABORATORY

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

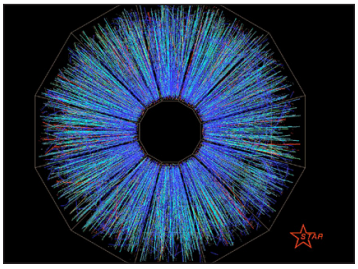
Operating Costs
Over $150 million per year

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.

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

Scientists from around the world collaborate on research at RHIC

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 appears to violate fundamental symmetries
- Temperatures reaching ~ 4 trillion degrees Celsius, substantially above the predicted melting temperature of neutrons and protons
- First indication of gluon saturation
- First measurements of significant gluon contribution to "missing" proton spin
- First evidence of how properties change above and below transition from early universe quark-gluon plasma to ordinary nuclear matter
- Important contributions to "jet physics"
- Unanticipated intellectual connections to other forefront science, including String Theory, ultra-cold atomic gases, matter-antimatter imbalance of the infant universe, and more conventional condensed matter such as high-temperature superconductors

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

Continued on p. 2

(11/10)

RHIC: Dazzling Discoveries, Bright Future (continued)

BROOKHAVEN NATIONAL LABORATORY

- 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

Strong productivity

> 350 refereed papers with > 35,000 citations

> 350 Ph.D.s in first 12 years, hundreds more in the pipeline

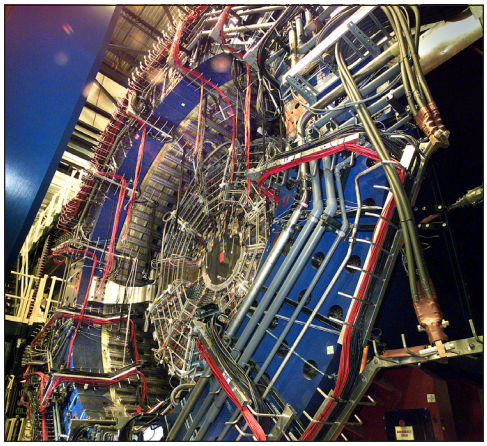
Internationally competitive

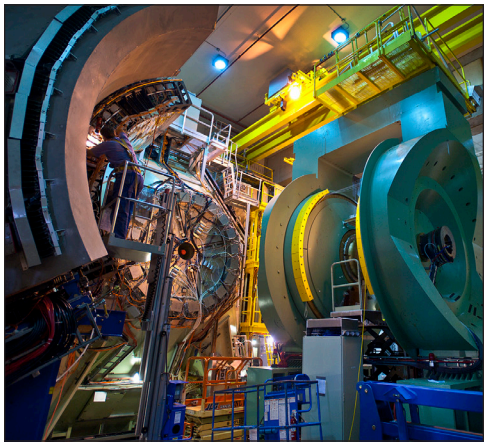
- Hits the "sweet spot" for detailed study of matter at the threshold of the universe due to extensive energy and ion species flexibility
- Dedicated primarily to heavy ion collisions (unlike LHC, where focus is high-energy physics)
- World's only spin-polarized proton collider
- The only operating collider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

Benefits beyond physics

- Production of medical radioisotopes for heart scans and cancer diagnosis/ treatment

The STAR Detector at RHIC





The PHENIX Detector at RHIC

- Beams used to study effects of space radiation, with strong NASA support
- Major accelerator technology breakthroughs that advance physics and other areas of science as well as cancer treatment systems
- R&D to advance energy-storage systems using superconducting magnets (ARPA-E and Army funding)
- R&D on accelerator technology with possible defense applications (ONR funding) in addition to relevance for discovery science at a future proposed electron-ion collider at RHIC (eRHIC)
- Accelerator technologies that could drive future, safer nuclear reactors
- Advances in computing and "big data" management and analysis applicable to many fields
- Supports ~850 BNL staff (including indirects) and > 1000 international scientific users

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