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*publisher:* BNL Community Relations Office  
P.O. Box 5000  
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www.bnl.gov

*writer & editor:* Marsha Belford  
belford@bnl.gov  
(631) 344-5053

*A Visitors' Guide to Summer Sundays 2006*

## Relativistic Heavy Ion Collider: a Perfect Liquid Discovered Here

*Discover for yourself a new state of matter thought to have last existed just after the Big Bang*

- On Sunday, August 20th, you are welcome to discover for yourself a state of matter that is thought last to have existed moments after the Big Bang — and to learn about its recent discovery at the Relativistic Heavy Ion Collider (RHIC) at Brookhaven Lab.

- As the world's newest, largest and highest energy accelerator for nuclear physics, RHIC is funded by the Office of Science of the U.S. Department of Energy.

- Operating since 2000, RHIC collides gold ions together to duplicate, on the atomic scale, the super hot, high pressure and extremely dense conditions that last existed immediately after the birth of the universe. (For a better idea of how RHIC works, see story on the back.)

- At these extreme temperatures and densities, physicists expected to observe some of the most basic particles of matter — quarks and gluons — freed from the protons and neutrons making up the gold nucleus to form what is called quark-gluon plasma.

- In 2005, RHIC was the site of one of the year's top scientific discoveries: what existed a few microseconds after the Big Bang is not the expected plasma of weakly interacting quarks and gluons — it seems to be a *liquid* of *strongly* interacting quarks and gluons!



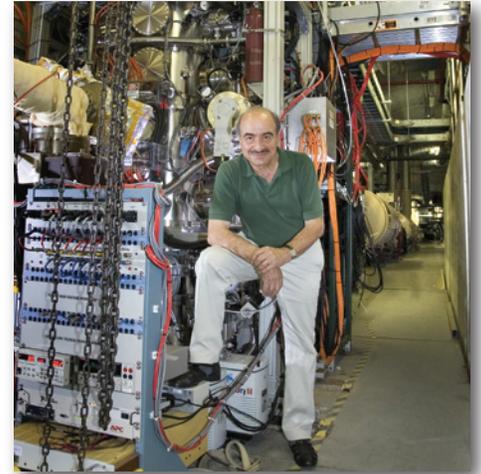
The Relativistic Heavy Ion Collider at Brookhaven Lab

- In fact, because it behaves exactly according to the rules of hydrodynamics, this state of matter is the most perfect liquid ever to have been discovered.
- Four teams of over 1,000 physicists announced this discovery, which is based on the analysis of collision data taken using two monumentally large and two smaller electronic detectors.
- When RHIC takes a break from colliding gold ions, it serves as the world's first and only collider of spin-polarized protons.
- Physicists use RHIC in this fashion to investigate a fundamental question about a well-known particle and a universal property: What is responsible for a proton's "spin"? (See story on the back.) — M.B.

## Meet the BNL Scientists Doing the Research

# Physicist Yousef Makdisi Measures Proton-Beam 'Polarization' In the Quest to Find Out What Is Responsible for a Proton's 'Spin'

- Within the subterranean, subway-like tunnel housing tubes of cryostat-contained superconducting electromagnets, miles of cables overhead in racks, and detectors of house-sized proportions, one RHIC staffer who is here to meet and greet you during the collider's Summer Sunday is physicist Yousef Makdisi.
- In addition to organizing your day at RHIC, Dr. Makdisi is in charge of one of several instruments that make a measurement important to RHIC's operations not as the world's highest-energy heavy-ion collider, but as the world's only collider of what are called spin-polarized protons.
- Dr. Makdisi oversees a particular "polarimeter" — a polarized hydrogen jet target polarimeter — which is an instrument that measures the percentage of the proton beam that is polarized in a certain direction.
- This measurement is important



Yousef Makdisi, Ph.D.,  
in front of a polarimeter at RHIC

## Scientific Terms Used at BNL Explained

### What Is a 'Relativistic Heavy Ion Collider'?

- As the name of a particle accelerator, the "Relativistic Heavy Ion Collider" is both a mouthful and a description of the world's largest machine for nuclear physics. So, taking the name apart word by word will help to understand what RHIC (pronounced "Rick") does.
- "Relativistic" means having a velocity at or near the speed of light. Near the speed of light, objects feel the effects of what is called special relativity, a theory describing time and motion proposed by Albert Einstein in 1905.
- In this example, "heavy" means having great mass. Hydrogen is the lightest element, with an atomic mass of about 1. With an atomic mass of about 196, gold is considered to be a heavy element.
- "Ion" means, in this case, an atom that has an electric charge. At RHIC, positively charged gold ions are made by taking gold atoms and stripping off 77 of each of their 79 electrons.
- A "collider" is a particle accelerator in which two beams of particles are accelerated in opposite directions to near the speed of light before they are directed at each other and caused to meet in high-energy collisions.
- Out of these collisions, new particles emerge, which are tracked by particle detectors. Data are later analyzed to understand the physics and, perhaps, to find something new — such as the recently discovered perfect liquid. — M.B.



Inside the subterranean tunnel that contains RHIC

because the accuracy of the experimental data gathered from polarized-proton collisions depends upon it.

- A proton is a positively charged subatomic particle found in the nucleus of every atom. The number of protons determines an atomic element's chemical properties.
- Although most of us haven't heard of spin-polarized protons, a lot of us have heard about or experienced MRI, which stands for magnetic resonance imaging.
- A method used by physicians to visualize tissue and organs inside our bodies, MRI relies upon the same two important properties: spin, which is the intrinsic angular momentum of a particle; and polarization, which, in this case, is the alignment of a particle's spin along a particular axis.
- Physicists collide beams of protons that are spin-aligned to look inside the proton. The goal is to find out what subatomic particles are responsible for the proton's spin — or if something else is involved. This is important because it will help explain the structure of the proton.

— Marsha Belford