

RHIC: In Pursuit of the Plasma



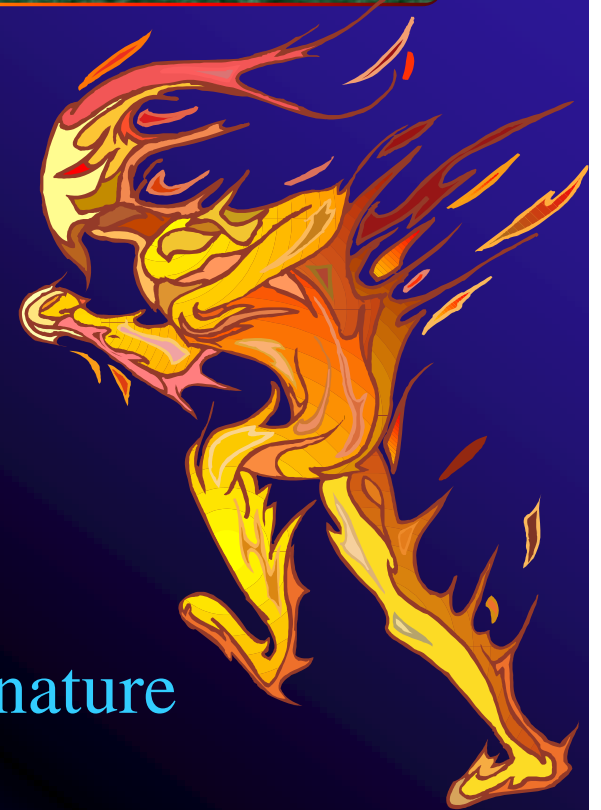
BNL Summer Sunday

8/26/01



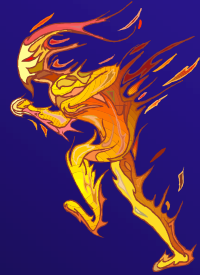
Briefing Outline

- Our Suspect is...
the Quark-Gluon Plasma (QGP)
- Who is a known informant...
about the basic building blocks of nature
- An All Points Bulletin has been issued...
QGP hide-outs are being monitored.

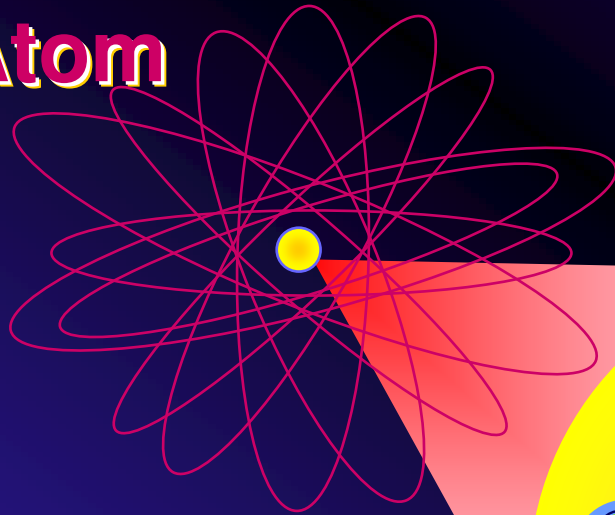


Quark-Gluon Plasma Dossier

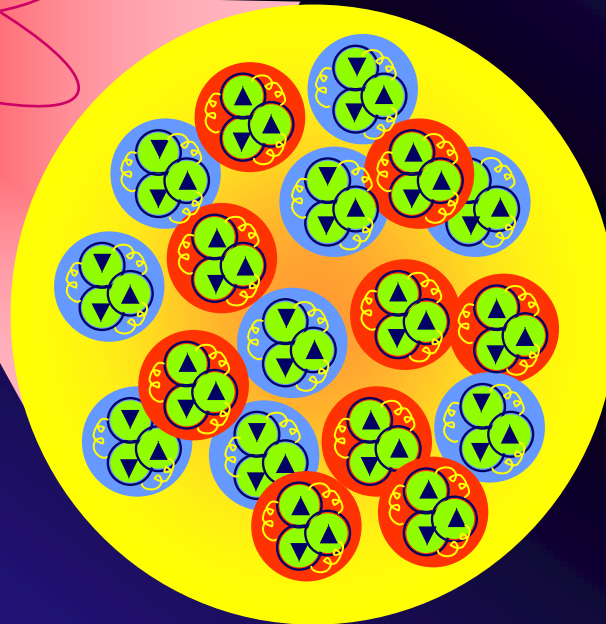
The QGP appears
after a *phase
transition...*



Atom



Nucleus



Key

- Proton
- Neutron
- ▼▲ Quarks
Held together
by gluons
- ⌘ Gluons

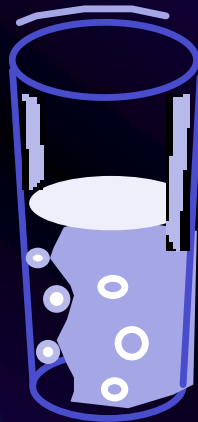
M.O. : Within the
QGP, the Quarks are
set free!

What is a phase transition?

ICE



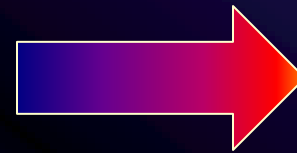
WATER



STEAM



**Add
heat**



**Add
heat**

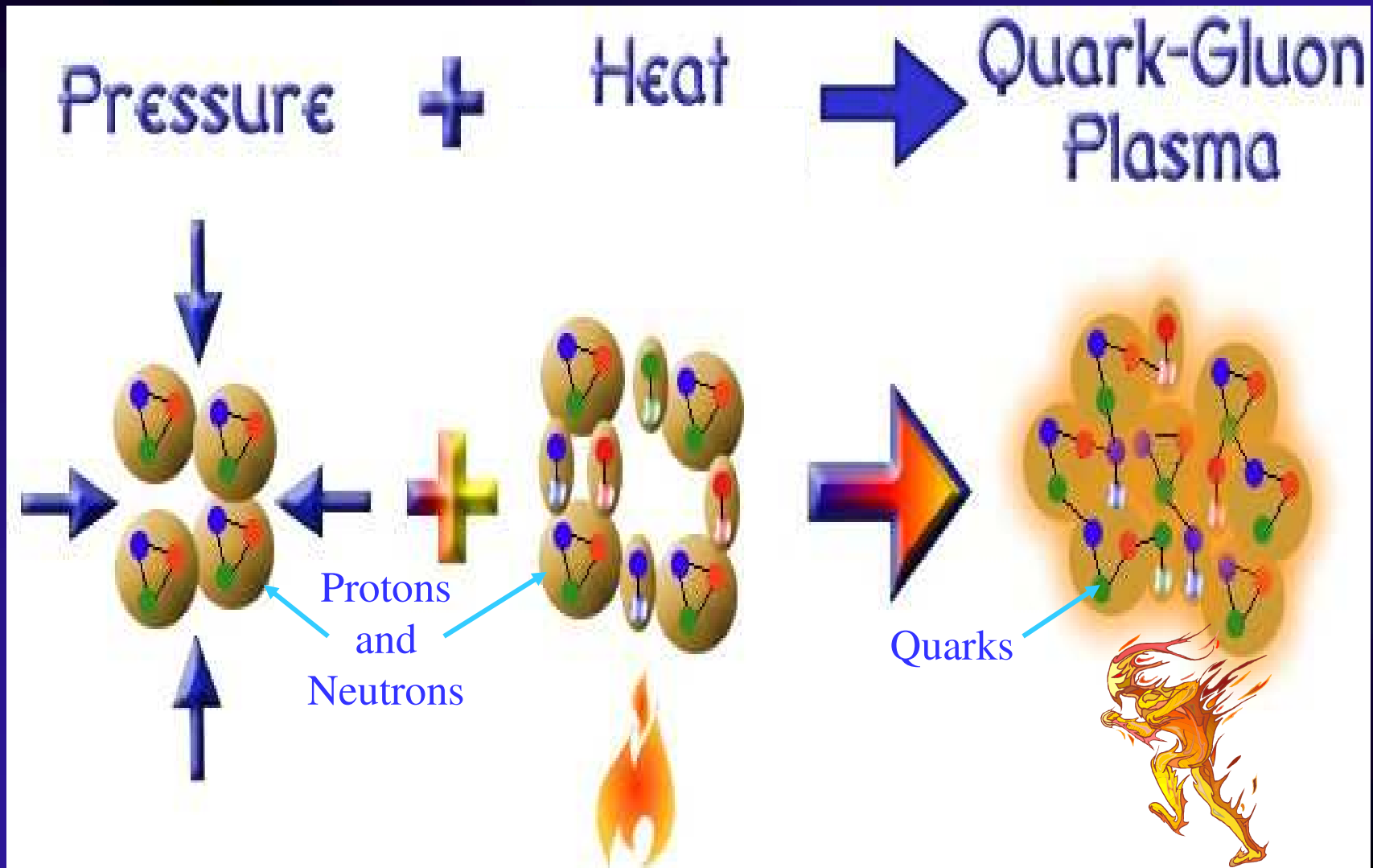
SOLID

LIQUID

GAS

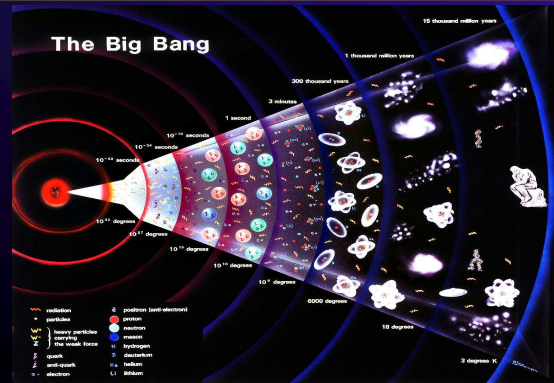
These are the phases of matter we see in our normal lives.

Phase Transitions and the QGP



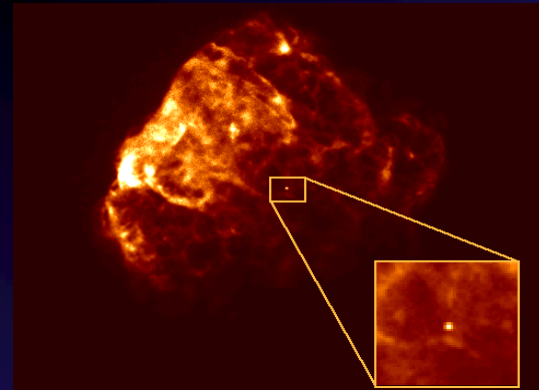
Quark-Gluon Plasma Hideouts

- The Early Universe



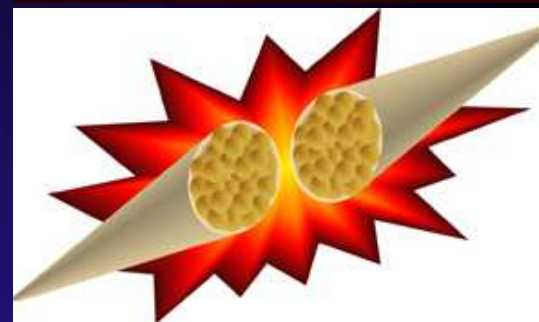
Hard to stake out.
It happened billions of years ago.

- Neutron Stars (possibly)



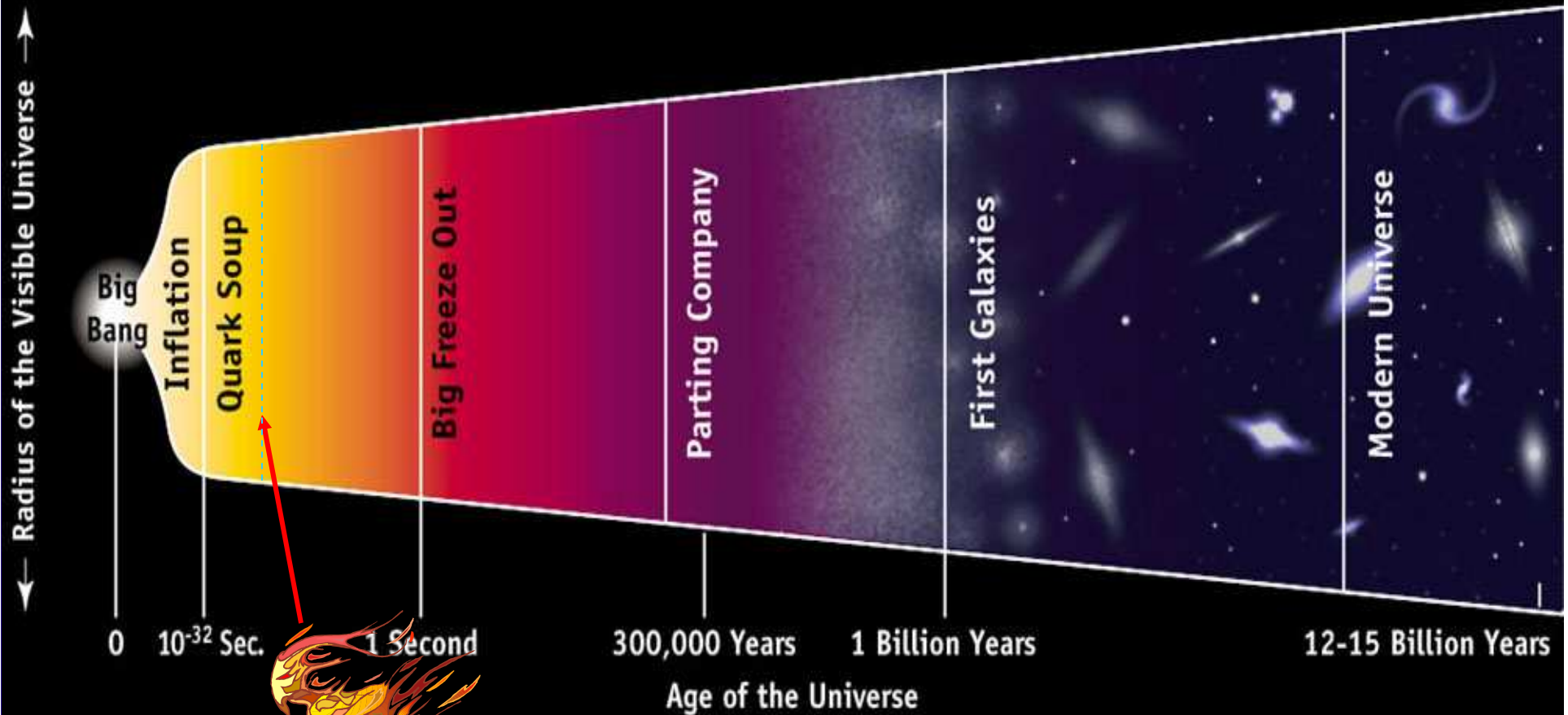
Hard to stake out.
They are very far away.

- Collisions of Nuclei



Easy to stake out.
We can make these ourselves!

The QGP in the Early Universe



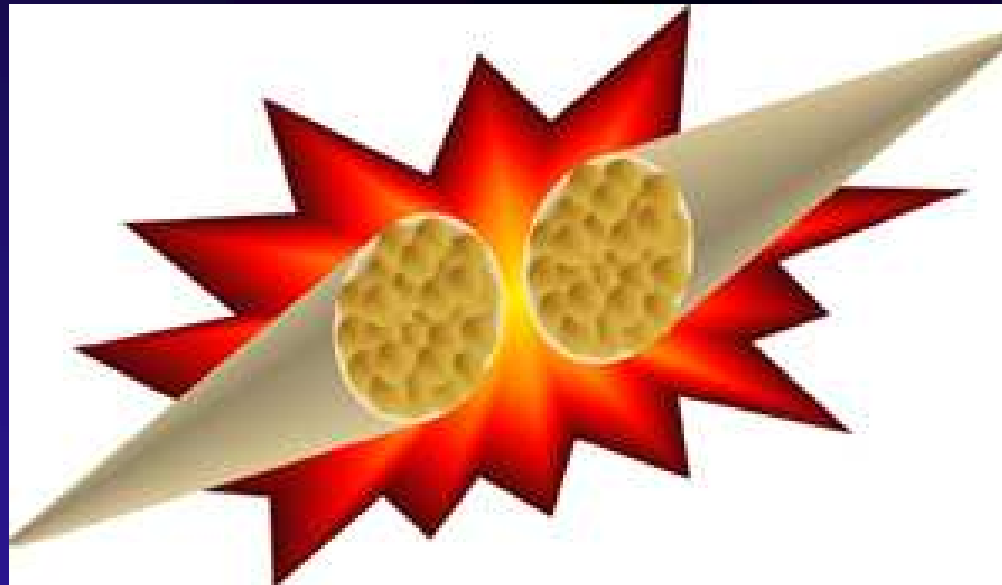
How To Catch A Plasma

Take two of the heaviest nuclei we can use.

Grab a particle accelerator, the **Relativistic Heavy Ion Collider, to accelerate them close to the speed of light.**

Crash them together to create our own QGP hide-out.

Surround the hide-out site with surveillance equipment.



A briefing on RHIC

Relativistic Heavy Ion Collider

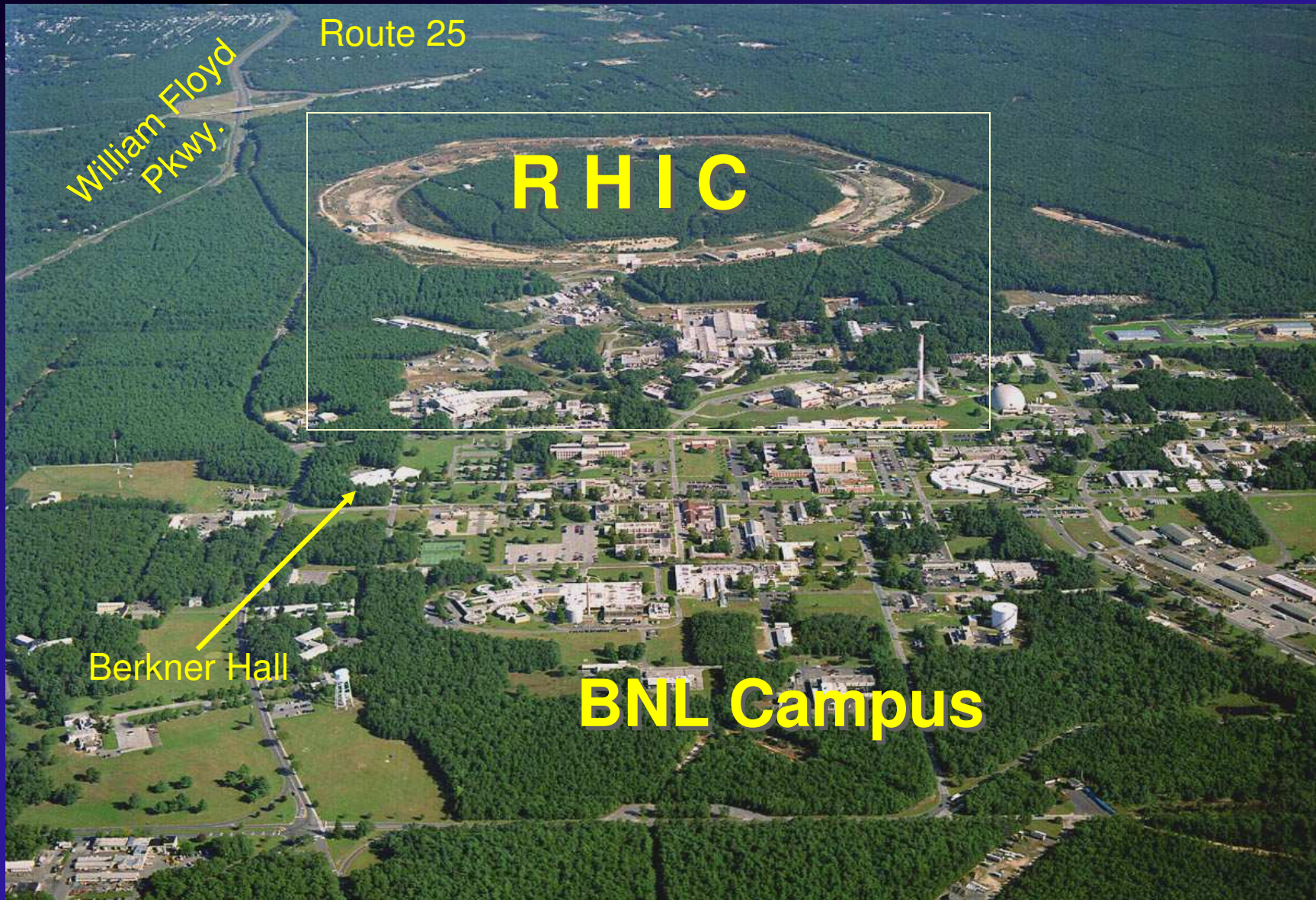
Einstein's relativity
 $E=mc^2$, near light speed

Elements like gold,
without electrons

Two ion beams
hit head-on



The Location of RHIC



Setting Up A Trap for the QGP



A briefing on RHIC

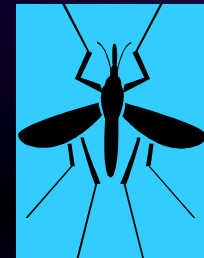
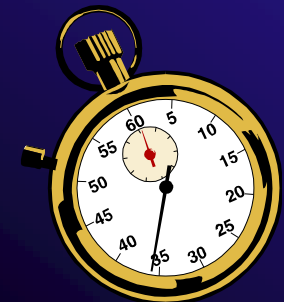
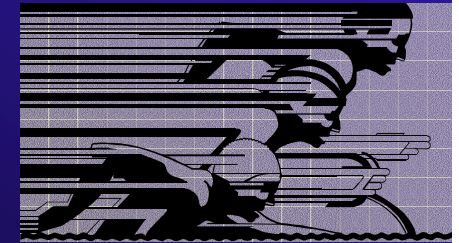
- RHIC's particle beams reach 99.995% of the speed of light!

That's 186,000 miles per second, or over 60 million miles per hour!!!

- There are billions of ions in RHIC when it is operating with thousands of collisions each second!

- The energy in each collision is about the same as two mosquitoes colliding.

- Over 20 years, less than one gram of gold is used.



A look inside the RHIC tunnel

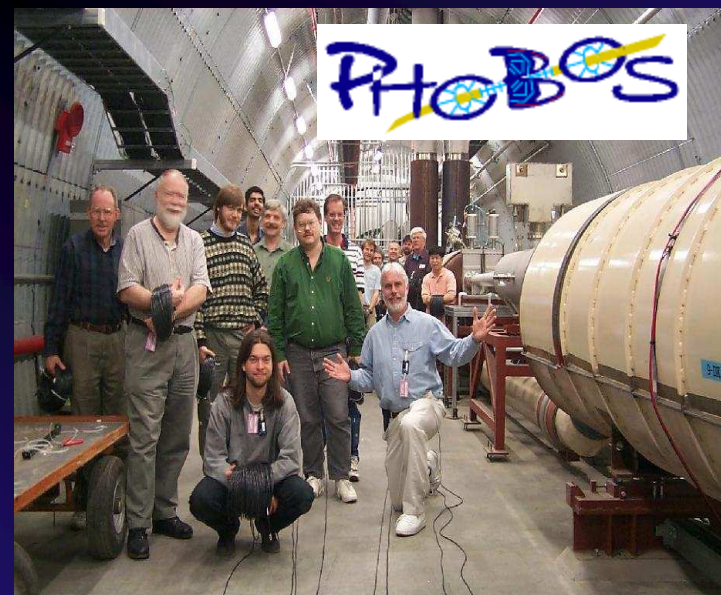
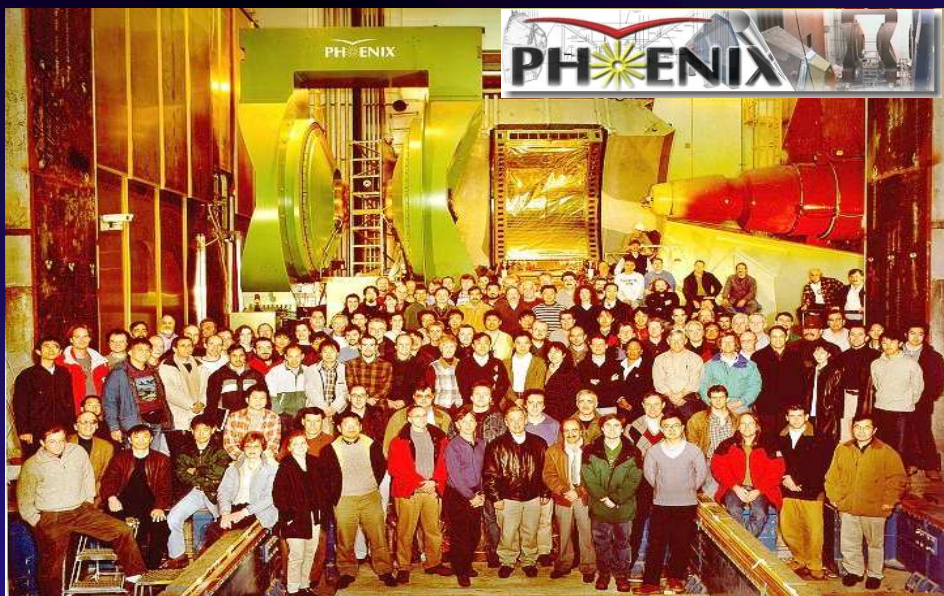
Over 1,600 miles of
superconducting cable
and over 78,100 pounds
of helium!



The magnets are cooled
to -450 degrees
Fahrenheit

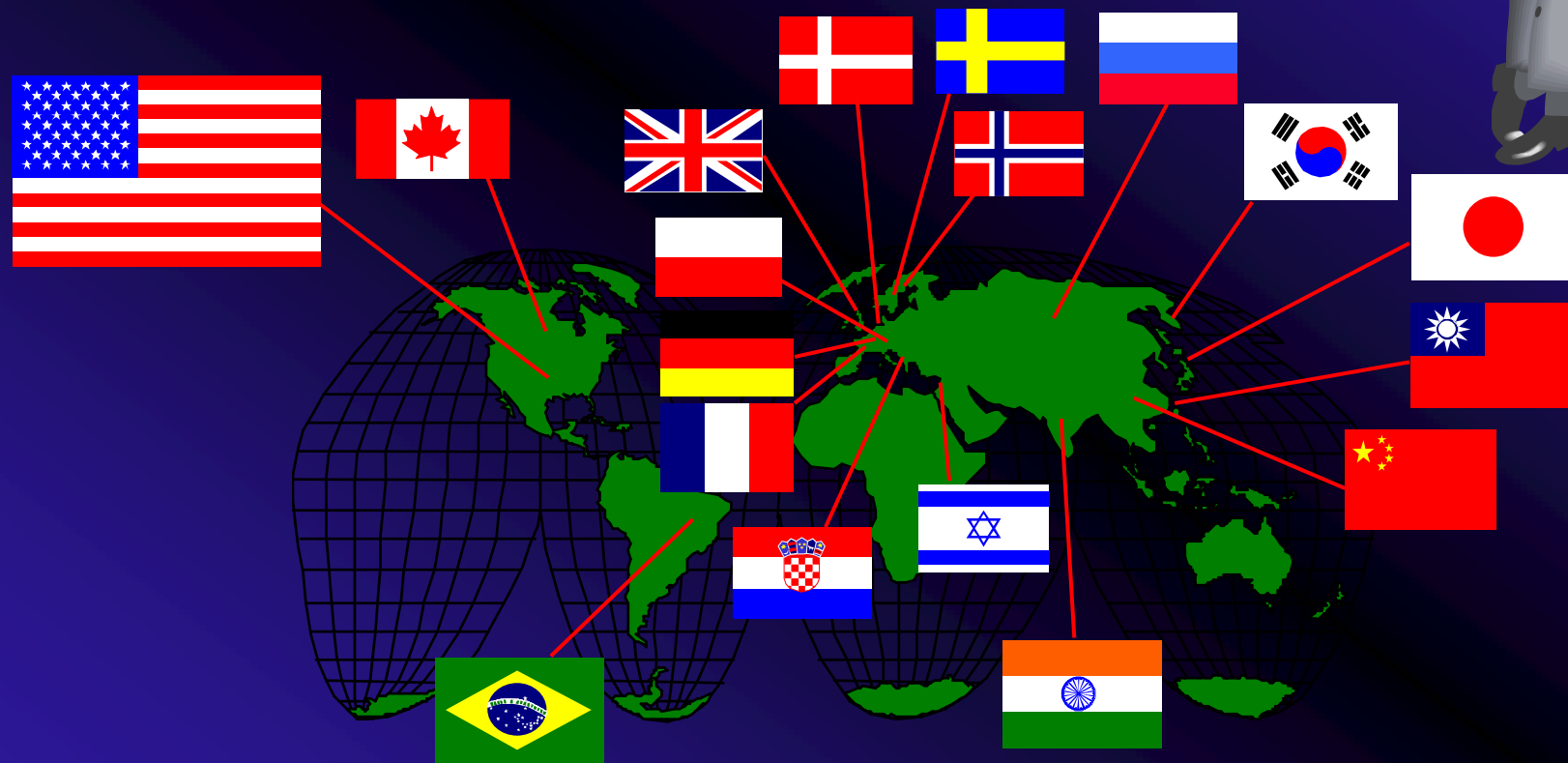
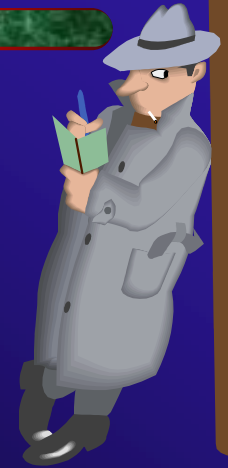


RHIC Surveillance Teams and Equipment



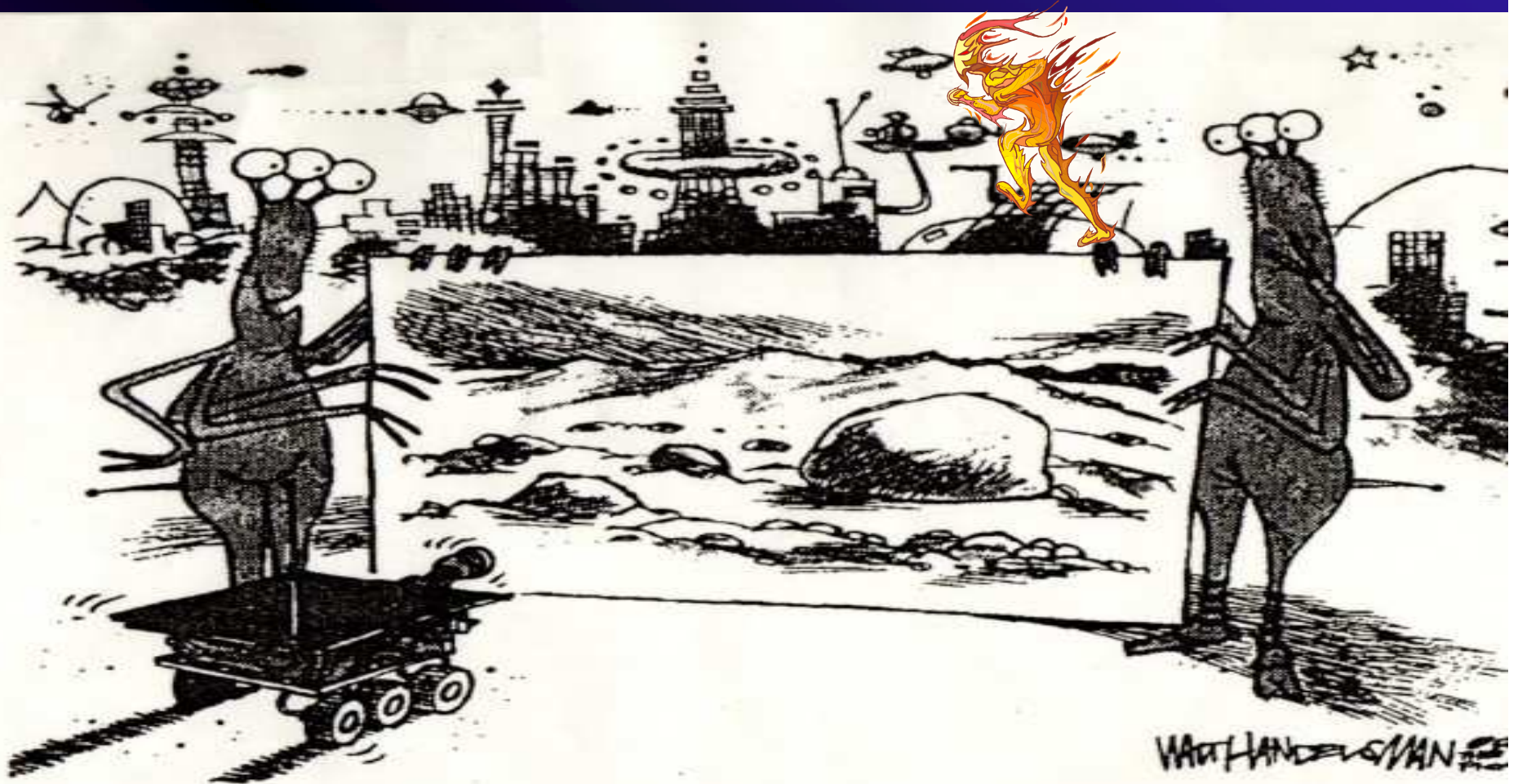
Mounting an International Operation

Detectives from all over the world are searching for the Quark-Gluon Plasma.



There are more than 1000 scientists participating in the 4 RHIC experiments.

The QGP: A Master of Disguise and Deception

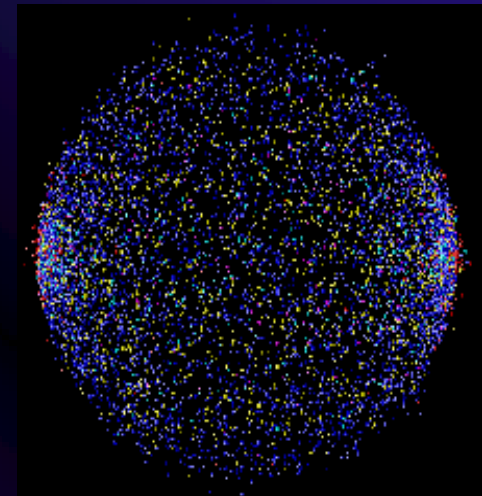
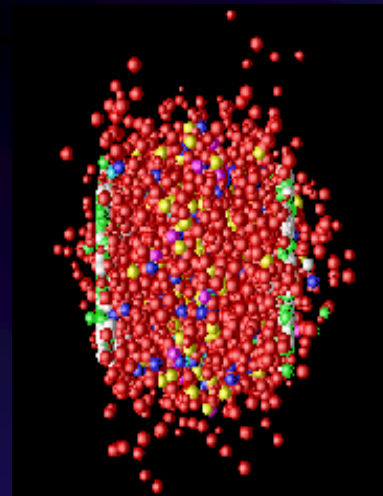
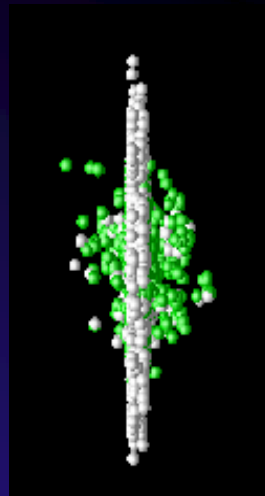
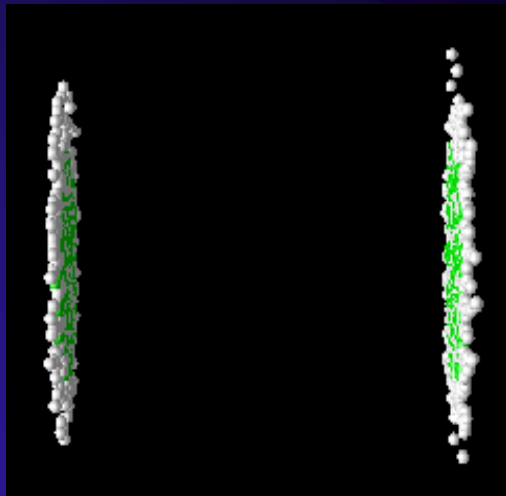


"...HOLD STILL, LARRY, IT'S TAKING ANOTHER PICTURE..."

Walt Handelman, New Orleans Times-Picayune

A Simulation of a Collision at RHIC

The elusive Quark-Gluon Plasma puts on a disguise and hides in a crowd.

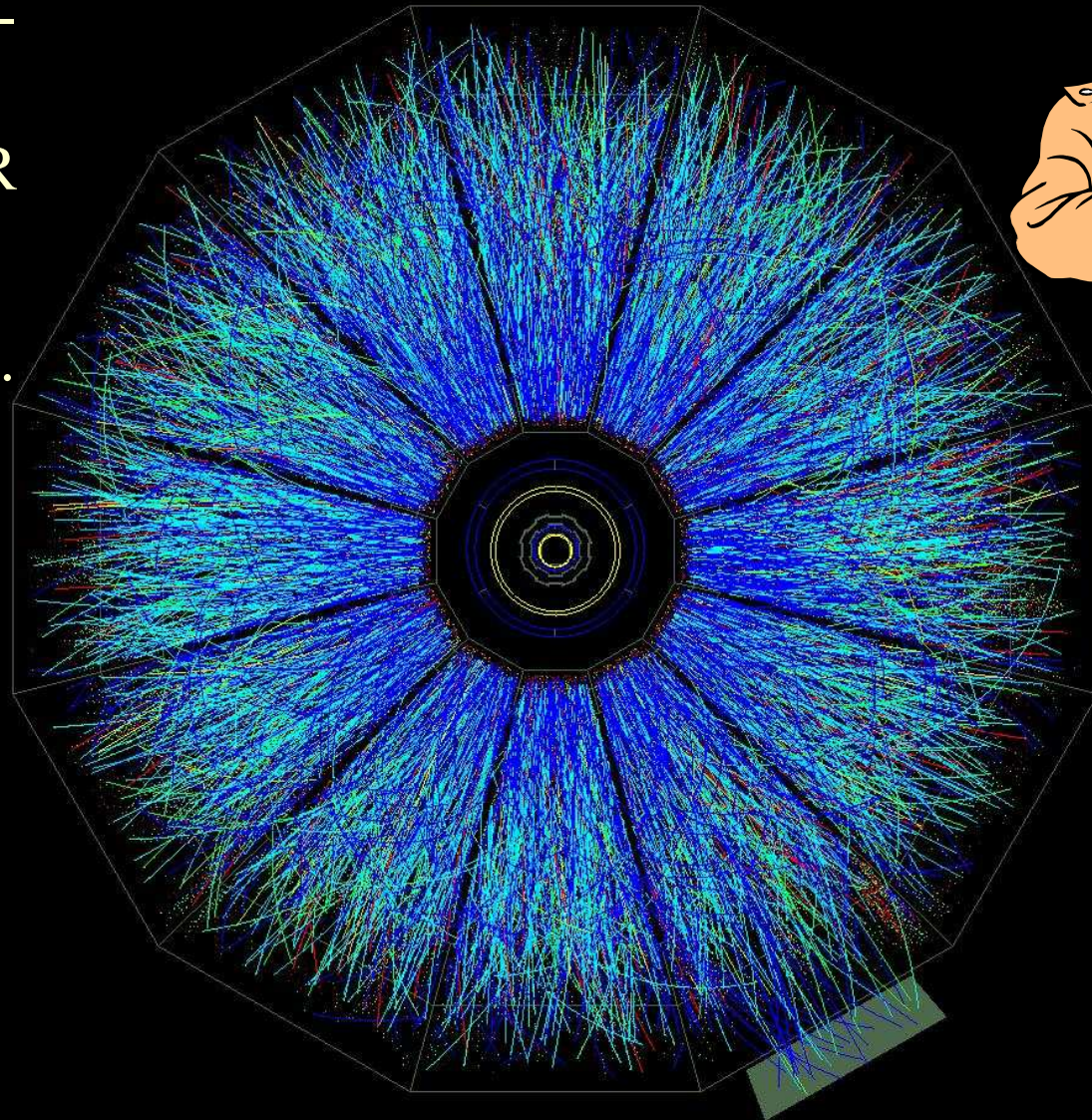


In a head-on Gold-on-Gold collision, there are thousands of particles produced!

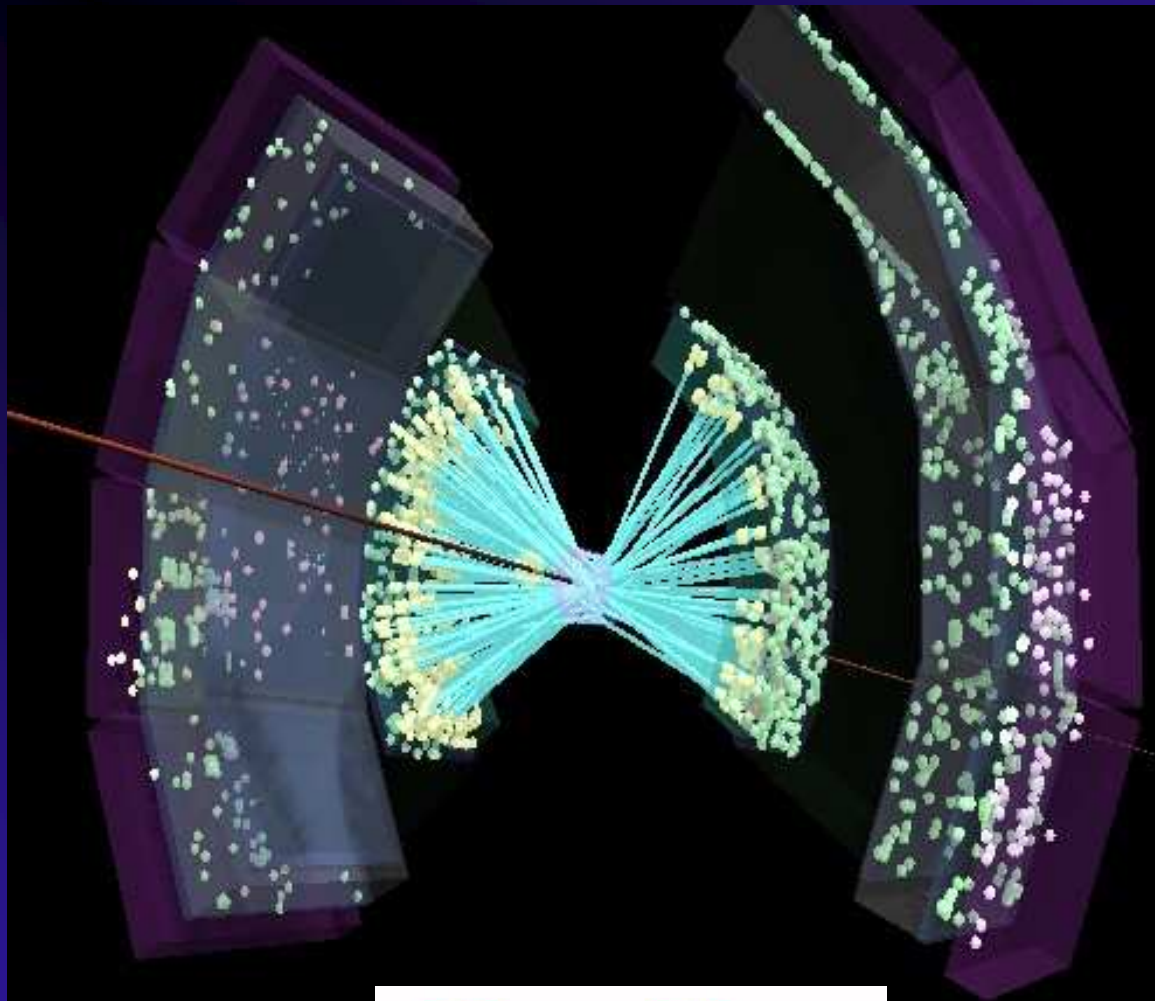
A Surveillance Photo of a Collision at RHIC

A single Gold-on-Gold collision as seen by the STAR experiment.

Taken this month.



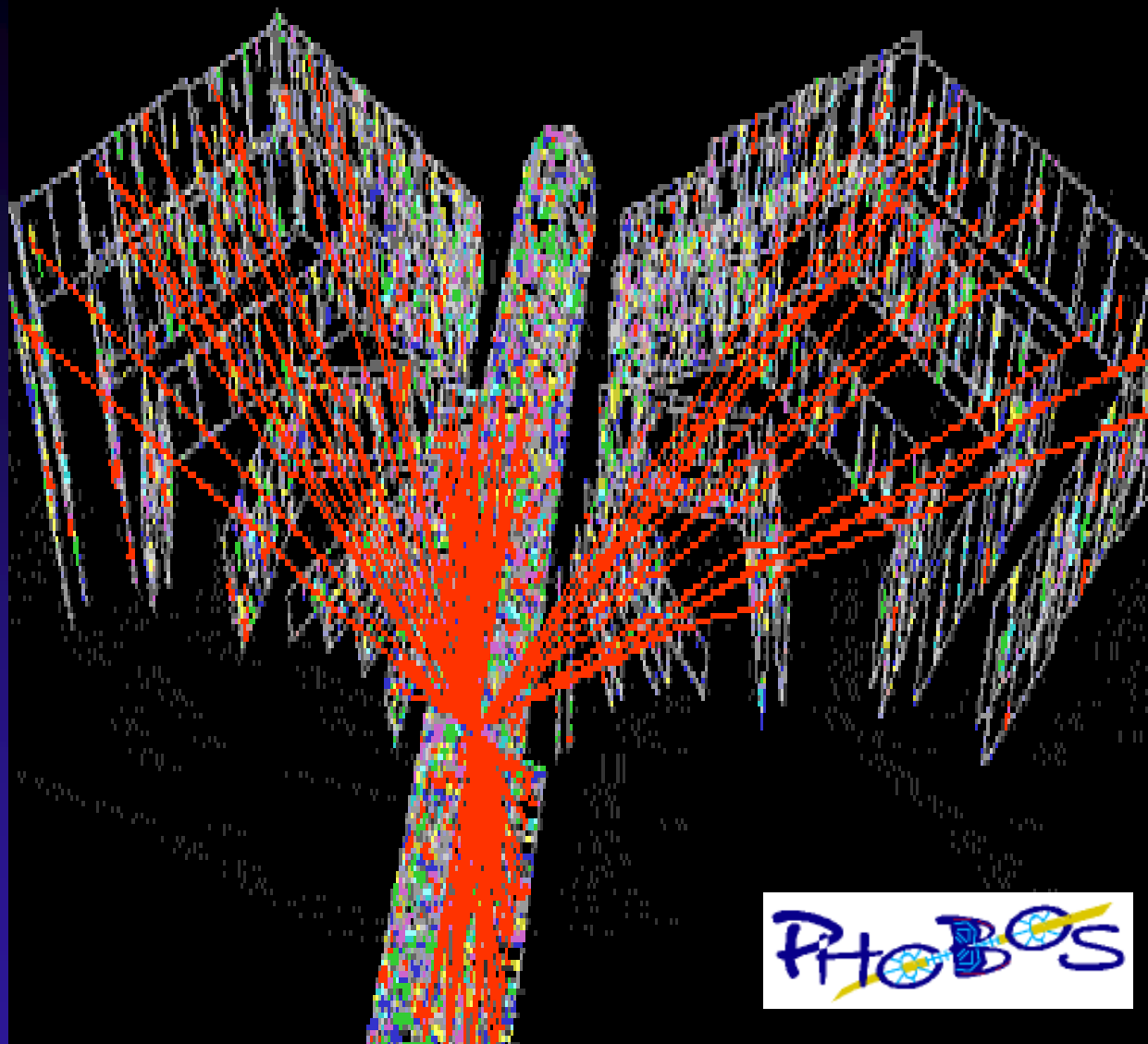
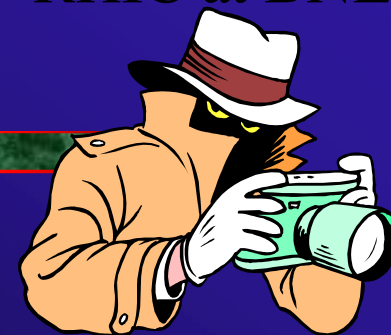
More Surveillance Photos



A single
Gold-on-
Gold
collision as
seen by
PHENIX.
Taken this
month.



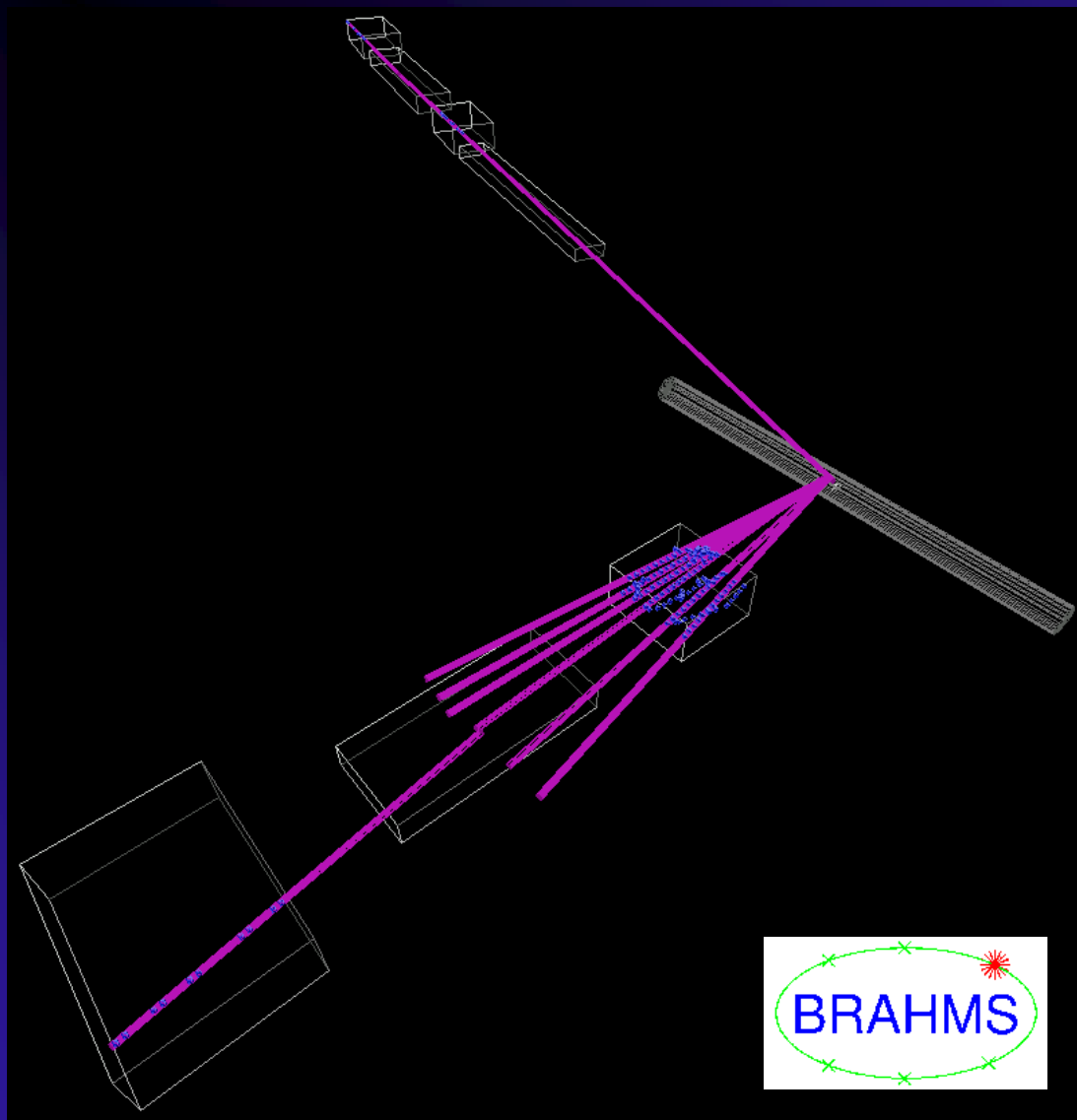
And More Surveillance Photos



A single Gold-on-Gold collision as seen by PHOBOS. Taken this month.



And Even More Surveillance Photos



A single Gold-on-Gold collision as seen by BRAHMS. Taken this month.

Debriefing: The Evidence So Far...

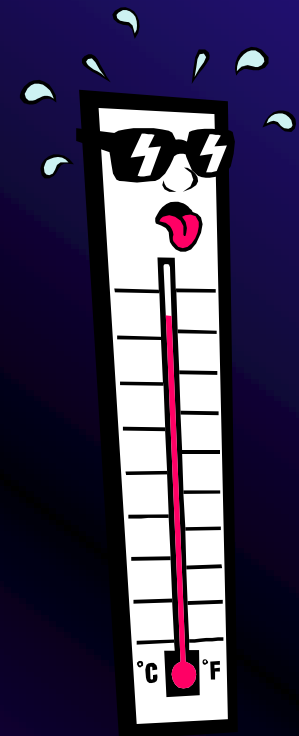
- The RHIC hide-out draws a large crowd of particles.



We count more than 5000 particles produced in each head-on collision!

- The RHIC hide-out's thermostat is set very high - *the QGP likes it hot.*

The temperature of the hide-out has been measured to be 2 trillion degrees Celsius, or 100,000 times the temperature of the sun!



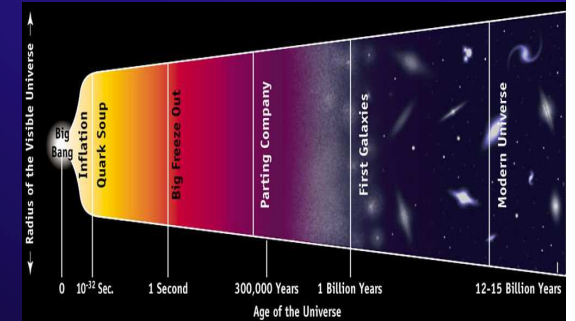
Debriefing: The Evidence So Far...

- The hide-out is beginning to look like the early universe - *a known QGP hide-out*.

We see almost as much anti-matter as matter.

- We may have already caught a glimpse of our suspect!

The picture is still fuzzy, but more data should clear it up.



Processing the Data as we speak!



**Racks of Personal
Computers
(running LINUX)**



Tape Robots for Data Storage

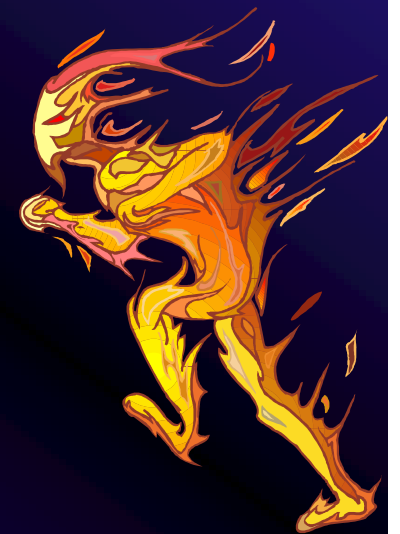


- Includes 1,200 individual CPU's!
- Disk storage equal to 5,000 home PC's (50,000 GigaBytes)!
- If we were to put each year's worth of data on floppy disks, we could pave all lanes of the LIE from here to New York City with them!

The Pursuit of the Plasma Continues

RHIC is taking data right now!

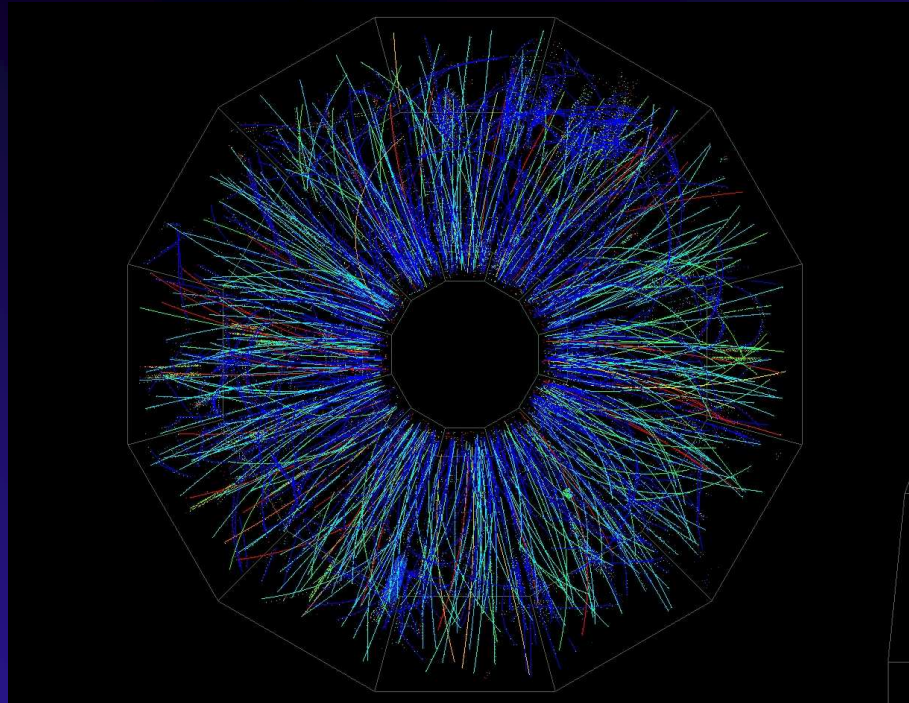
The detectives are busy sifting through the data.



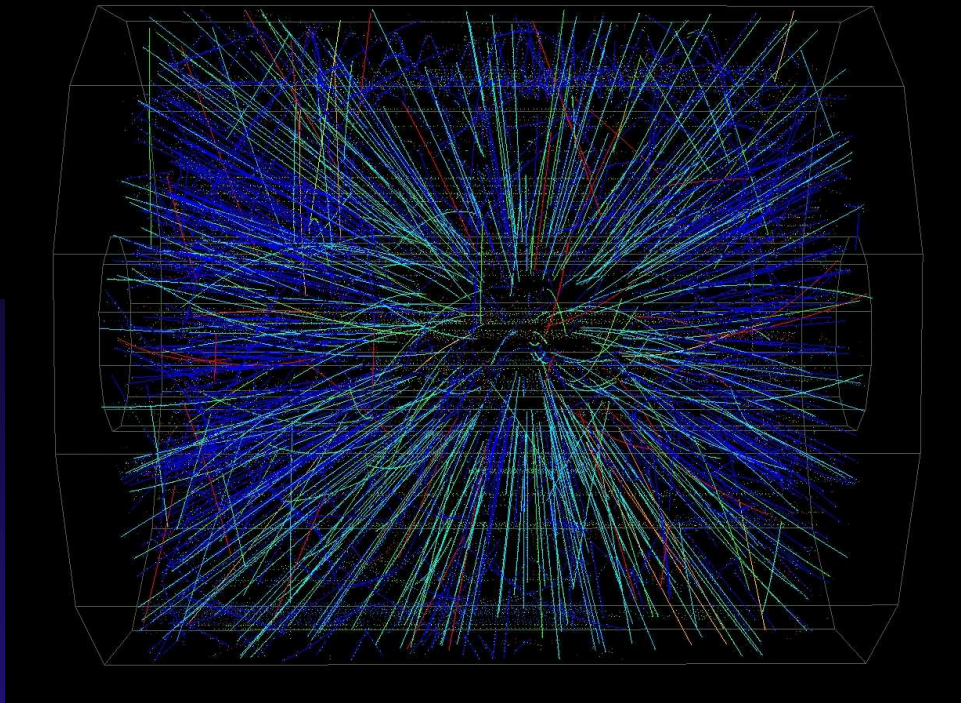
Our suspect is still at large.

Stay tuned for more news soon...

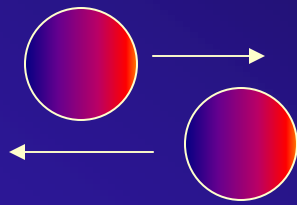
The RHIC Hide-Out: Drawing a large crowd



Data Taken June 25, 2000.

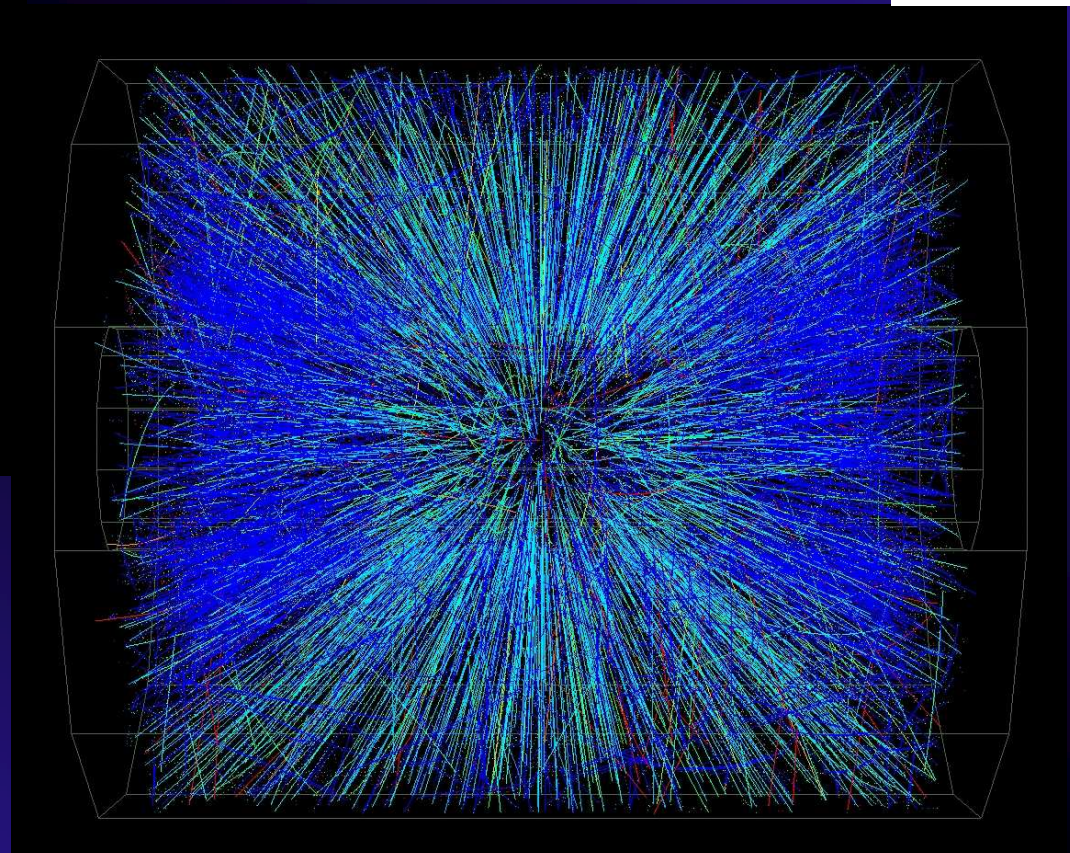
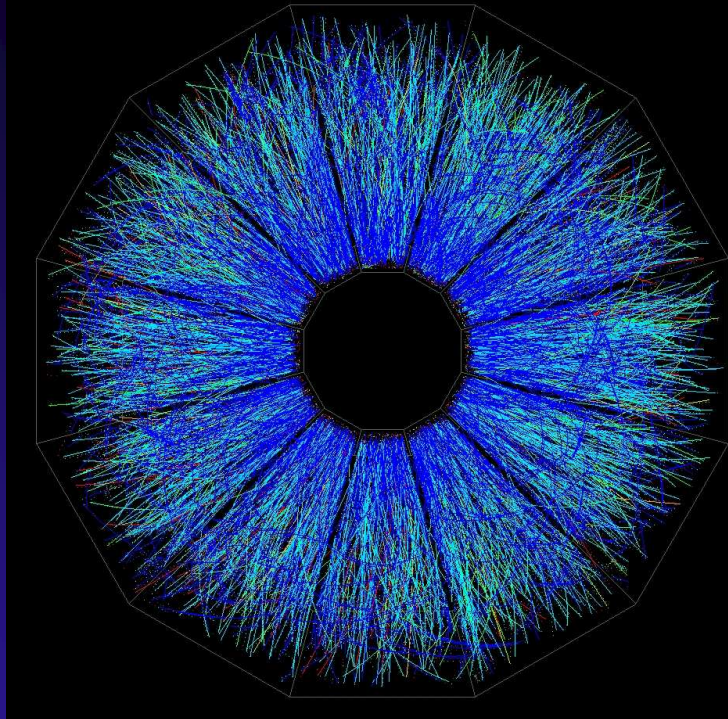


A grazing collision

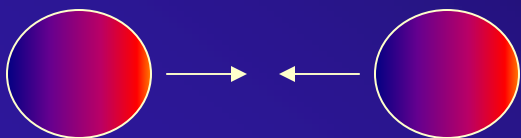


The RHIC Hide-Out: Drawing a large crowd

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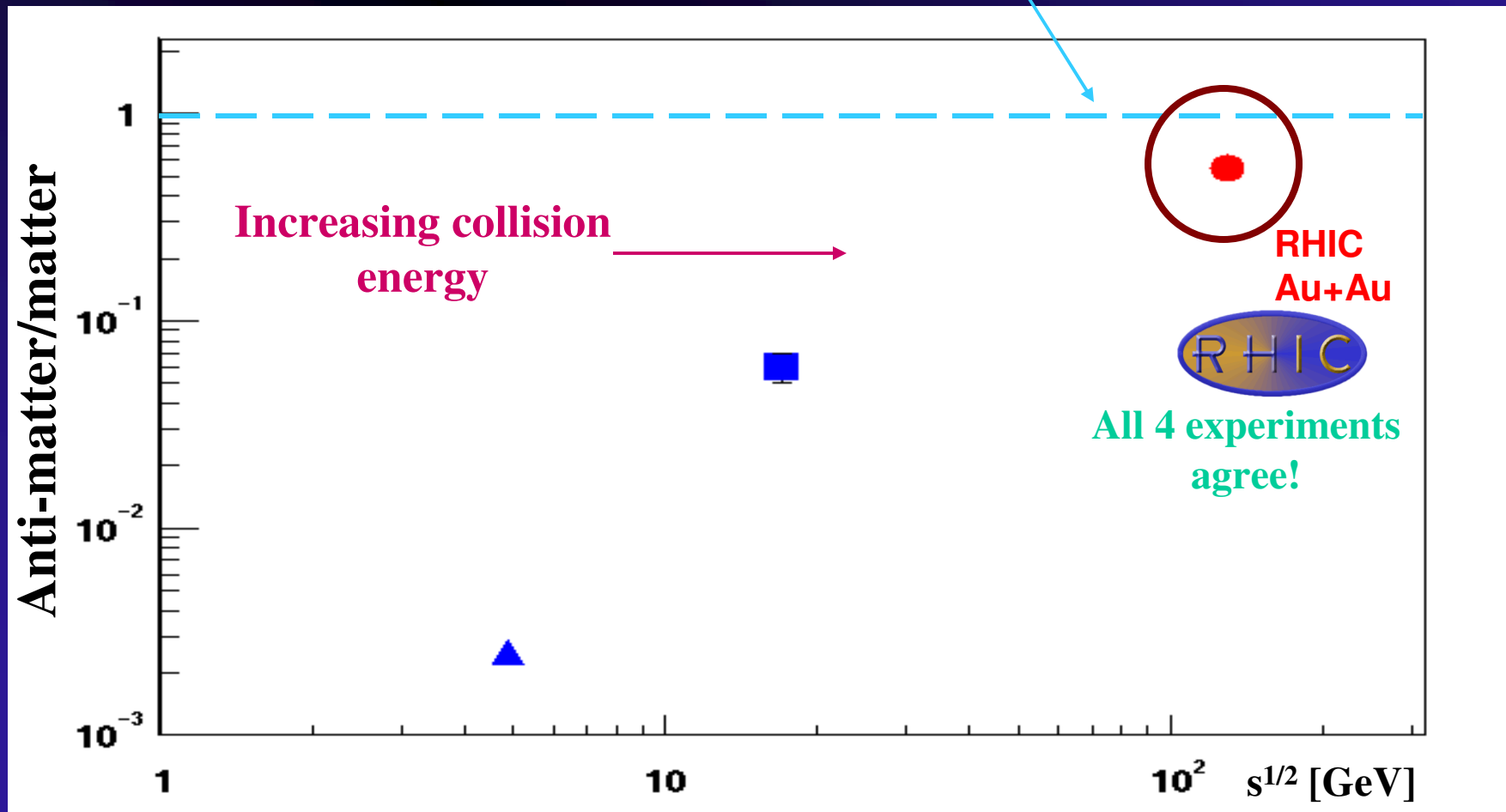


A Head-on Collision

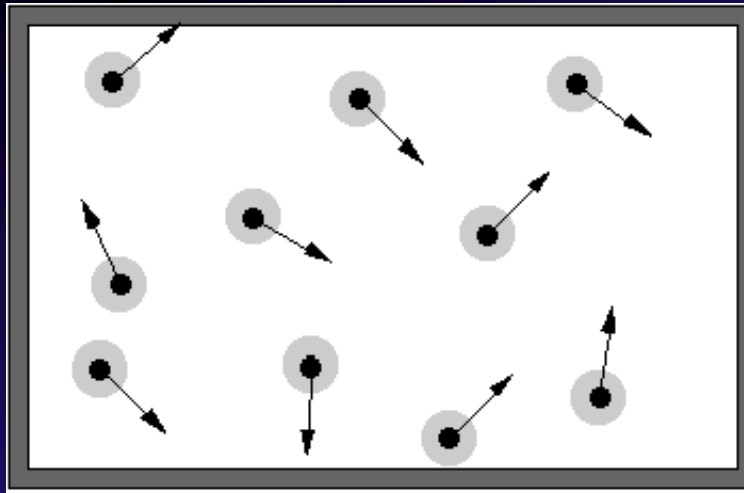
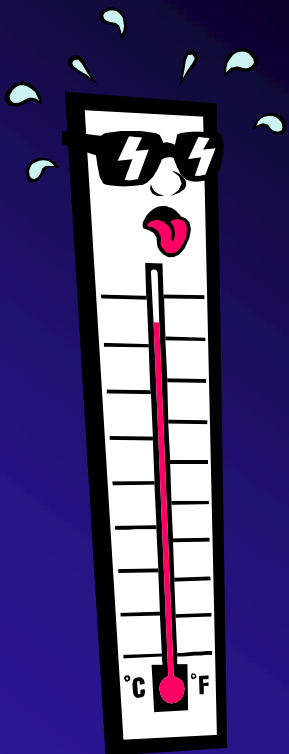


The RHIC Hide-Out and the Early Universe

In the Early Universe, the ratio of
Anti-matter to matter was about 1.0.



The RHIC Hide-Out: How hot is it?



The center of the collision acts like a gas.

The temperature of any gas can be determined from the velocity of the molecules (or particles).

