



Experiments on Dense Matter Evoke Big Bang

By JAMES GLAVIN

STONY BROOK, N.Y., Jan. 16 — Scientists at Brookhaven National Laboratory have used a particle accelerator to smash the nuclei of gold atoms together to make the highest density of matter ever created in an experiment, they announced at a conference here today.

The accelerator, the Relativistic Heavy Ion Collider, smashed the gold nuclei together at nearly the speed of light. Physicists studied the debris speeding away from the collisions and concluded that they had produced densities more than 20 times higher than those that exist within the nuclei of ordinary matter.

Temperatures in the compressed matter reached more than a trillion degrees. Scientists believe that large amounts of matter at those densities and temperatures first existed a few millionths of a second after the start of the Big Bang, the colossal explosion in which the universe is thought to have been born.

Beyond offering clues to the birth of the universe, the results may also shed light on the compressed matter at the cores of exploding stars called supernovas, the stellar cluders called neutron stars and the situations when energy-laden, fast-moving particles in space, cosmic rays, happen to collide.

If confirmed, the results announced today will break record densities ever achieved at CERN, a European particle physics laboratory in Geneva. Brookhaven scientists said measurements at the accelerator, often referred to as RHIC (pronounced rick), indicated they had produced matter with a density

physicist who is the spokesman for the group of scientists working on one of the four large particle detectors at the accelerator, said the main piece of evidence for concluding that RHIC produced the densest matter yet in any experiment is the large numbers of particles, amounting from the collision points. They indicate, he said, that terrific densities had been produced.

Dr. William A. Zajc, a physicist at Columbia University and a spokesman for another of the detector groups, said that the aim of the work was one of the most basic possible. "We hope to learn that matter

Smashing nuclei to seek clues to the birth of the universe.

from, which the entire universe emerged," Dr. Zajc said.

Dr. Harris, Dr. Zajc and other scientists working at the Brookhaven accelerator presented their results here today at a conference called "Quark Matter 2001," being held on the Long Island campus of the State University of New York at Stony Brook. More than a thousand scientists from institutions around the world worked to produce the dense matter, they said.

Dr. Zajc said that despite his team's excitement over the results from the new accelerator, which produced its first gold collisions last June, they still represented only the

clues that hold the quarks together. The quarks and gluons are bound so tightly within protons and neutrons that they can never be extracted, no matter how violent a collision is produced between individual protons and neutrons.

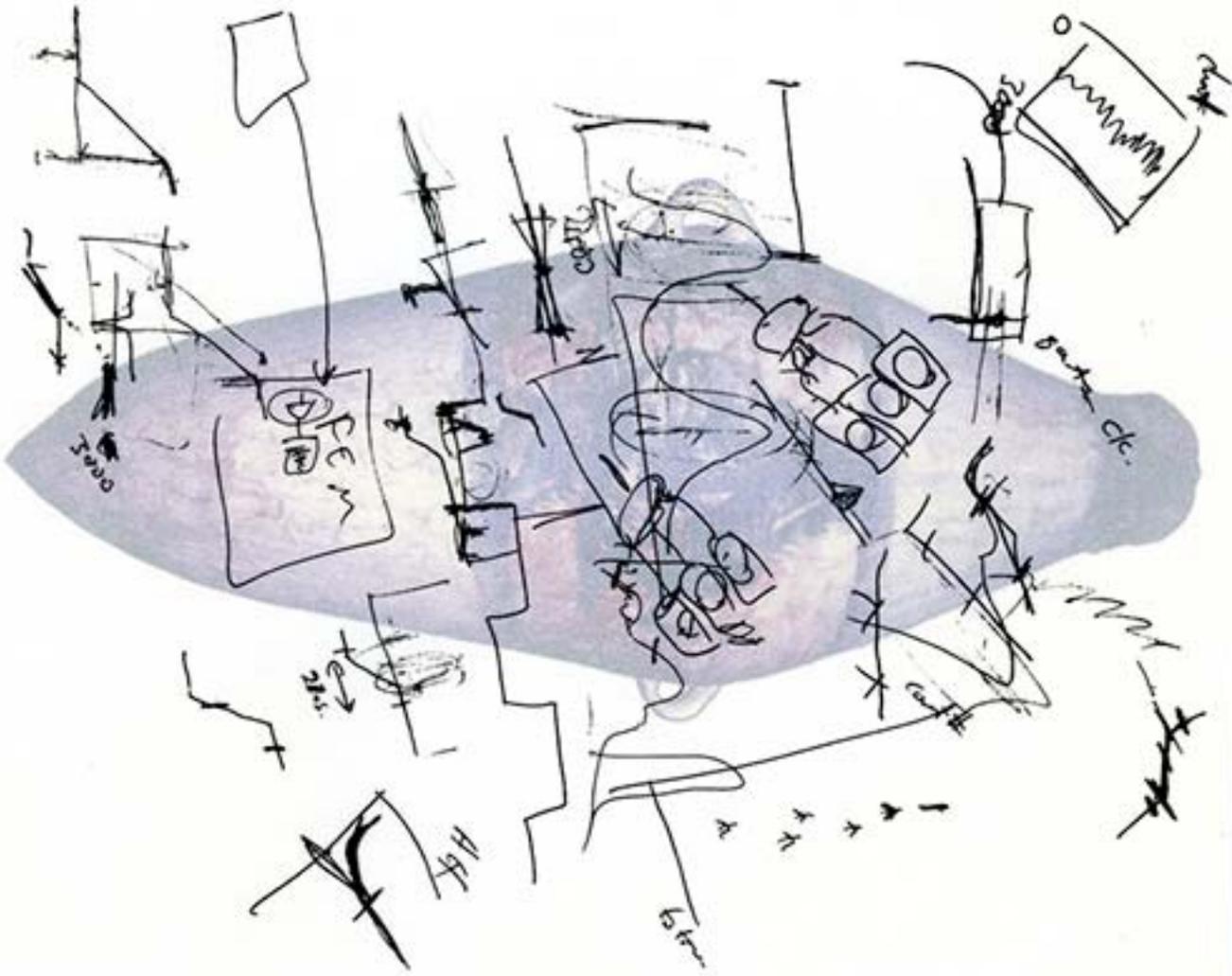
But theory predicts that if heavy nuclei like those of gold, containing dozens of protons and neutrons, are smashed together, the quarks and gluons should briefly spill out and mix together in a sort of liquid — the quark-gluon plasma.

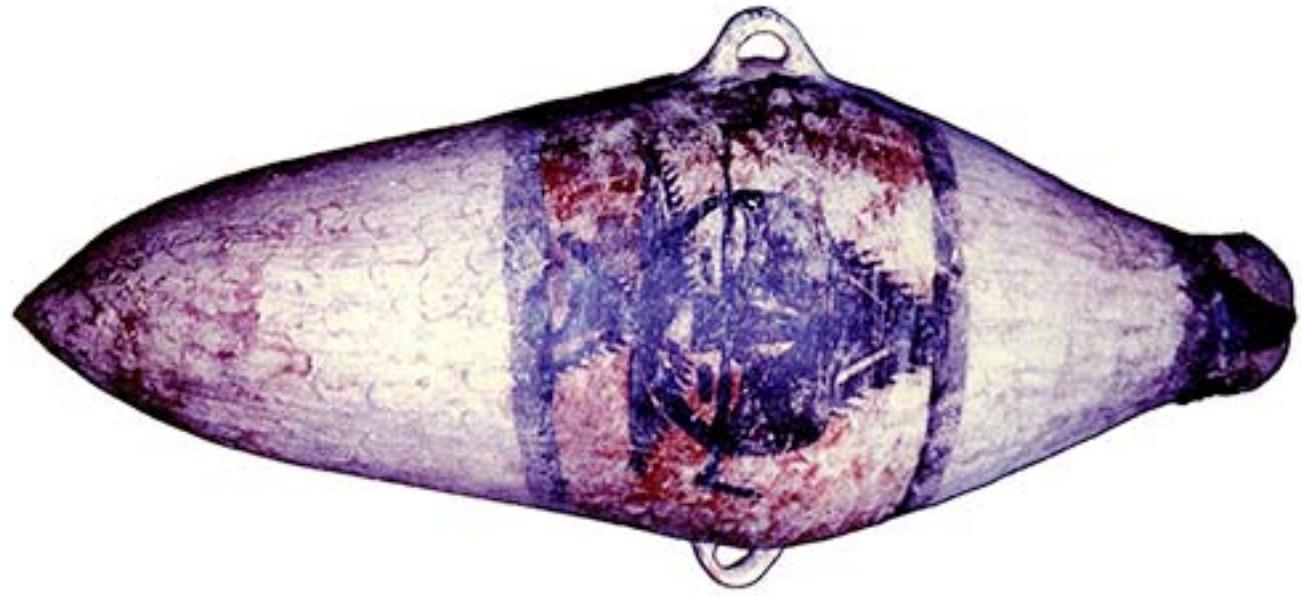
Physicists would like to find out whether their theory is correct in predicting this result and, if it is, to study the properties of the plasma in order to learn more about the birth of the universe and the centers of dense and exploding stars.

In their announcement last year, CERN physicists did not claim to have created a complete quark-gluon plasma, but they said their data did imply that the quarks and gluons had begun spilling out and roaming freely, a process called deconfinement. Some RHIC physicists say the evidence from CERN's experiments does not sufficiently support this claim, but a CERN physicist, Dr. Carlos Lourenço, reiterated the earlier conclusions at a talk here this morning.

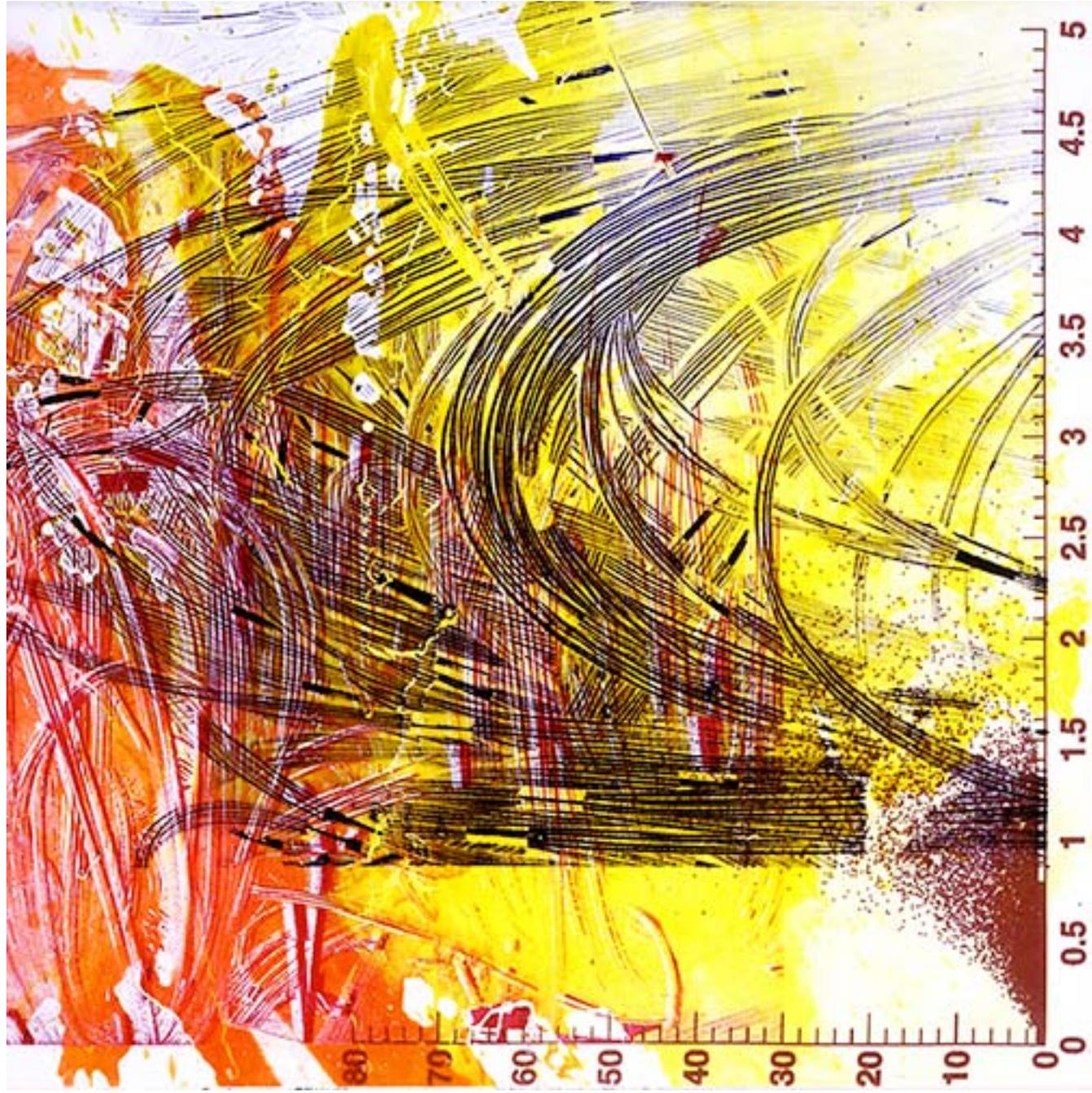
To explain the data without assuming deconfinement, Dr. Lourenço said later in an interview, "you have to go through a lot of complications which are unnatural."

As the scientists build their case for this new state of matter, Dr. Nicholas P. Samios, a Brookhaven physicist who was not involved in the work, said that the importance of the experiments lay in the minute detail









```

// src/main/cpp/BufferFilesTool.cpp
BufferFilesTool::BufferFilesTool() {}
BufferFilesTool::~BufferFilesTool() {}

int BufferFilesTool::nb = 0;
int BufferFilesTool::nbBytes = 0;

// TREF2 = new TREF2{"TREF2", "TREF2", 30, 0, 3, 30, 0, 3};
// TREF4 = new TREF2{"TREF4", "TREF4", 30, 0, 3, 30, 0, 3};

int BufferFilesTool::nbFiles = 0;
for (int i = 0; i < nbFiles; i++) {
    // if (IsPositive(i)) { nbBytes += nb;
    // nb = files->GetEntry(i); }
}

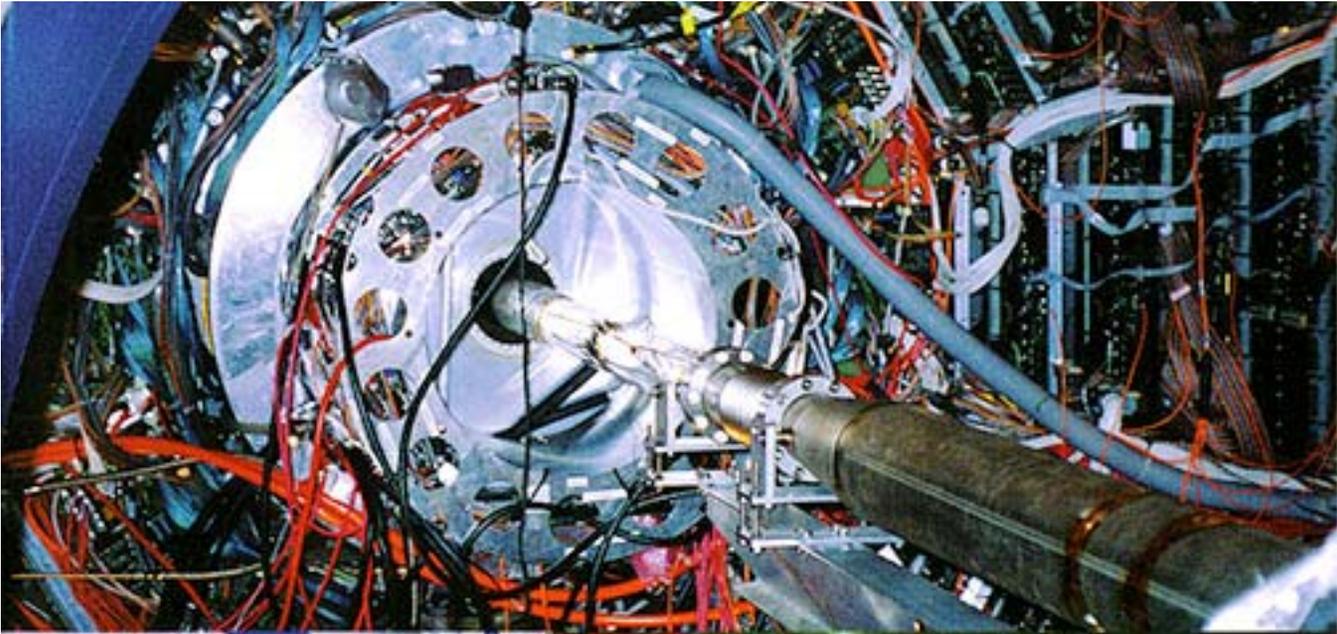
if (GlobalBlock_GlobalIter == 0) {
    pFileRow->Fill((float)npoolGet((float)emcIncluent));
    npoolIncluent = emcIncluent;pool[1][1];
    npoolIncluent = emcIncluent;pool[0][0] + emcIncluent;pool[0][1];
    npoolIncluent = 0;
    npoolIncluent = 0;
    for (int i = 2; i < 3; i++) {
        npoolIncluent += npoolIncluent;pool[i][1];
        for (int j = 0; j < 3; j++) {
            npoolIncluent += npoolIncluent;pool[j][1];
        }
        poolIncluent->Fill((float)npoolIncluent, (float)npoolIncluent);
        poolIncluent->Fill((float)npoolIncluent, (float)npoolIncluent);
        poolIncluent->Fill(-1);
        for (int i = 0; i < 3; i++) {
            poolIncluent = 0;
            for (int j = 0; j < 3; j++) {
                poolIncluent += emcIncluent;
            }
        }
        poolIncluent->Fill(0);
        for (int i = 0; i < 3; i++) {
            poolIncluent = 0;
        }
        // leaving other change, we calculate the new cluster size
        for (int i = 0; i < 3; i++) {
            if (emcIncluent > 0) {
                poolIncluent->Fill(emcIncluent);
            }
            if (emcIncluent < 0) {
                poolIncluent->Fill(0);
            }
            for (int j = 0; j < 3; j++) {
                poolIncluent->Fill(emcIncluent);
            }
        }
    }
    for (int i = 0; i < 3; i++) {
        poolIncluent->Fill(0);
    }
    if (emcIncluent > 0) {
        poolIncluent->Fill(0);
    }
}

// the print
// emcIncluent = 0;
// emcIncluent = 0;
// emcIncluent = 0;

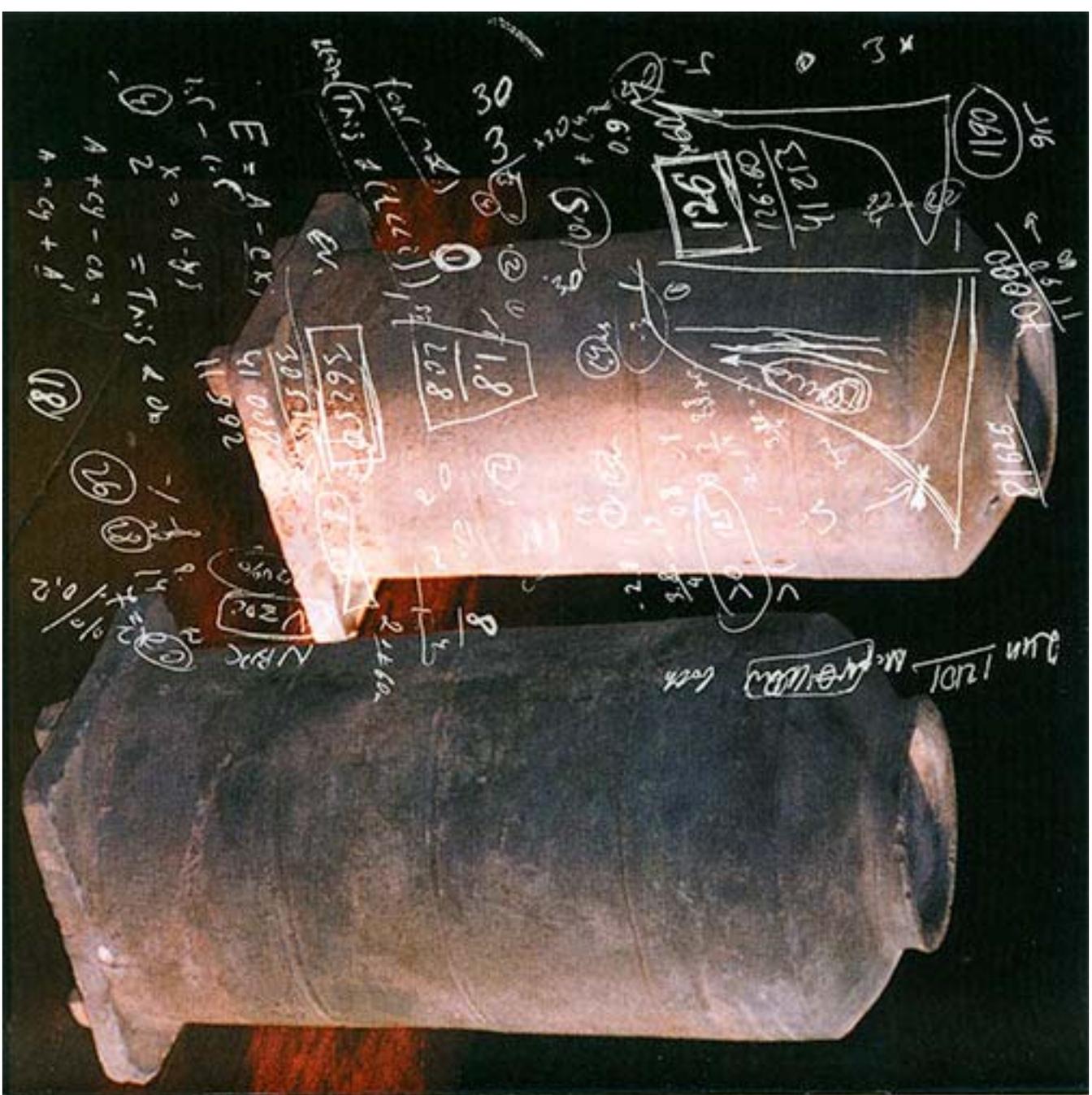
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COOK'S Sup of Fire Quarks
 By JAMES CLARKE 1993

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 ... not mutter
 ... quark nuggets
 ... quarks

$1000 = 2000P + 1000Q$

$2000P + 1000Q = 1000$

$2000P = 1000 - 1000Q$

$P = \frac{1000 - 1000Q}{2000}$

$P = \frac{1000}{2000} - \frac{1000Q}{2000}$

$P = \frac{1}{2} - \frac{1}{2}Q$

$2000(\frac{1}{2} - \frac{1}{2}Q) + 1000Q = 1000$

$1000 - 1000Q + 1000Q = 1000$

$1000 = 1000$

$1000 = 1000$

$1000 = 1000$

... the strength of
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ИЗВЕЩАНИЕ
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$$20K + 200 \frac{857}{838} = 20091 + 915 \times 60 = \underline{12991}$$

$$\frac{20091}{200} = 0.582$$

$$\frac{20091}{21118} = 0.951$$

$$\frac{866}{200} (24 \text{ m.k.h}) = 58.2\%$$

$$\frac{20091}{200} (24 \text{ m.k.h}) = 58.2\%$$

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Cook a Soup of Free-Range Quarks

By JAMES GLANZ

UPTON, N.Y. — Those pesky quarks

In groups of three, scientists believe, they combine to form the protons and neutrons that combine in the atomic nucleus. But the quarks will not come out and roam freely.

Yes, scientists have smashed protons to smithereens by knocking parts of them together in particle accelerators. But because of the odd way particles called gluons bind them together, even collisions in particle accelerators do not allow the quarks to set off on their own.

Close together, quarks exert little force on one another. But as the distance increases, the strength of the attraction grows and grows without end. In the chaos of a proton smashup, however, former trios of quarks cannot find each other again, no matter how great the force of attraction. So, with the blessing of Einstein's famous equivalence of mass and energy, the laws of physics allow some of the energy of the collision to create new quarks that become companions to the would-be fugitives.

That process leaves the original quarks inside violent showers of ordinary particles made of several quarks again. The forces relax, and the quarks never appear.

But physicists have a plan to free quarks. Using the Relativistic Heavy Ion Collider, or RHIC, at Brookhaven National Laboratory here, they hope to create not just a few free quarks, but a soup of thousands of them.

Dr. Thomas Ludlam, a Brookhaven physicist, is a director of the effort's scientific program. Standing beside two upright, 75-ton rings of steel booming like giant handdrums, Dr. Ludlam pointed to a spot midway between them where he said quarks would be freed, at least for a fraction of a second.

Dr. Ludlam said that was one of six spots around RHIC, a ring 2.4 miles in circumference, where course

Research may shed light on the Big Bang and other theories.

Just streaming beams of gold nuclei, each holding hundreds of protons and neutrons, will collide at nearly the speed of light. If all goes well, those particles will do what pairs of them can never do: crack open and allow free quarks and gluons to mix together in a hot, dense soup called a quark-gluon plasma.

Eventually, Dr. Ludlam said, the results should shed light not just on basic particle theories but also on the Big Bang — the enormous explosion in which the universe is thought to have been born — as well as the origin of mass and weight in the universe and the nature of empty space itself.

Physicists at RHIC (pronounced "rick") presented some of their first results at a conference in Stony Brook last week, announcing that gold-gold collisions had produced the

As interesting as the simple matter of free quarks would be, physicists are hoping to use those experiments to answer more detailed questions about the so-called strong force, which the gluons carry as they bind quarks together in protons, neutrons and more exotic hadrons like pions, kaons and J/psi particles.

Physicists believe the theory called quantum chromodynamics describes the strong force, but many of its predictions — including the existence of the quark-gluon plasma — remain untested. Dr. Edward Shuryak, a theoretical physicist at SUNY-Stony Brook, said another of those predictions was that empty space should be permeated with a kind of background energy that can be thought of alternately as a source of pressure or a molasses-like goo that interacts with particles like quarks.

Under ordinary circumstances, the theory predicts, the quarks receive much of their mass through a sort of friction or drag caused by the background energy. Oddly enough, in the trillion-degree temperatures and terrific densities generated by the gold-gold collisions, that background energy should melt away, Dr. Shuryak said. In those instants, he said, the hot plasma is like a bubble expanding against the pressure of nothingness.

Scientists hope that by pressing against it with the quark-gluon plasma, they can determine exactly what that pressure is. They would also like to examine debris from the explosion to find hints of that "melted vacuum" inside the plasma. That research will take place in parallel with experi-

```

}
return(ISOKE);
}

// The following member function places
// the Phoenix detector into a running
// state from which it will start the
// data collection process.....
int Partition::Start()
{
void Mholder;
SEBObject MpSEB;
ATPObject MpATP;
sprintf((char *)RCStatus,RCStateStr,"Busy");
RCStatus,RCState = RCBUSY;

ActionD.GlobalLock("Starting Run");
cout << "Partition::Start on " << PartitionName << endl;

runNumber = runNumberD.getNextRunNumber();
RCStatus,RunNumber = runNumber;

if (UseEVB) {
// If the Logger is on, then set the file rule
if (RCStatus.UseLogging) {
if (pCurBufferBoxD)
pCurBufferBoxD->setFileRule(FileRule);
else
cout << "Error setting file rule, no current buffer box" << endl;
}
ATPList.reset();
while(ATPList.current()) {
holder = (void *)ATPList.next();
pATP = (ATPObject *)holder;
if (UseThreads) {
pthread_create(&pATP->EVBtid,NULL,PExecATPStart,holder);
cout << "Spawned thread = " << pATP->EVBtid << endl;
} else {
pATP->Start();
}
}
}
}
}

```

