# Early Universe was a liquid: First results from the Large Hadron Collider's ALICE experiment

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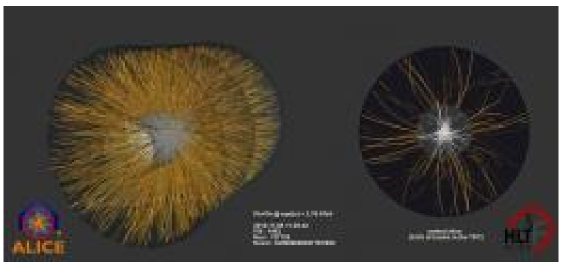


Real lead-lead collision in ALICE

(PhysOrg.com) -- In an experiment to collide lead nuclei together at CERN's Large Hadron Collider physicists from the ALICE detector team including researchers from the University of Birmingham have discovered that the very early Universe was not only very hot and dense but behaved like a hot liquid.

By accelerating and smashing together lead nuclei at the highest possible energies, the ALICE experiment has generated incredibly hot and dense sub-atomic fireballs, recreating the conditions that existed in the first few microseconds after the Big Bang. Scientists claim that these mini big bangs create temperatures of over ten trillion degrees.

At these temperatures normal matter is expected to melt into an exotic, primordial 'soup' known as quark-gluon plasma. These first results from lead collisions have already ruled out a number of theoretical physics models, including ones predicting that the quark-gluon plasma created at these energies would behave like a gas.

Although previous research in the USA at lower energies, indicated that the hot fire balls produced in nuclei collisions behaved like a liquid, many expected the quark-gluon plasma to behave like a gas at these much higher energies.

Scientists from the University of Birmingham's School of Physics and Astronomy are playing a key role in this new phase of the LHC's programme which comes after seven months of successfully colliding protons at high energies. Dr David Evans, from the University of Birmingham's School of Physics and Astronomy, and UK lead investigator at ALICE experiment, said: "Although it is very early days we are already learning more about the early Universe."

He continues: "These first results would seem to suggest that the Universe would have behaved like a super-hot liquid immediately after the Big Bang."

The team has also discovered that more sub-atomic particles are produced in these head-on collisions than some theoretical models previously suggested. The fireballs resulting from the collision only lasts a short time, but when the 'soup' cools down, the researchers are able to see thousands of particles radiating out from the fireball. It is in this debris that they are able to draw conclusions about the soup's behaviour.

## The ALICE Experiment

Physicists working on the ALICE experiment will study the properties, still largely unknown, of the state of matter called a quark-gluon plasma.

This will help them understand more about the strong force and how it governs matter; the nature of the confinement of quarks – why quarks are confined in matter, such as protons; and how the Strong Force generates 98% of the mass of protons and neutrons. The ALICE detector is placed in the LHC ring, some 300 feet (100 metres) underground, is 52 feet (16 metres) high, 85 feet (26 metres) long and weighs about 10,000 tons.

The ALICE Collaboration consists of around 1000 physicists and engineers from about 100 institutes in 30 countries. The UK group consists of eight physicists and engineers and seven PhD students from the University of Birmingham. It plays a vital role in the design and construction of the central trigger electronics (the ALICE Brain) and corresponding software. In addition, the UK group is making an important contribution to the analysis of ALICE data.

During collisions of lead nuclei, ALICE will record data to disk at a rate of 1.2 GBytes (two CDs) every second and will write over two PBytes (two million GBytes) of data to disk; this is equivalent to more than three million CDs (or a stack of CDs (without boxes) several miles high). To process these data, ALICE will need 50,000 top-of-the-range PCs, from all over the world, running 24 hours a day.

ALICE utilises state-of-the-art technology including high precision systems for the detection and tracking of subatomic particles, ultra-miniaturised systems for the processing of electronic signals, and a worldwide distribution network of the computing resources for data analysis (the GRID). Many of these technological developments have direct implications to everyday life such as medical imaging, microelectronics and information technology.

**More information:** Two papers detailing this research have been submitted for publication and posted on: xxx.lanl.gov/abs/1011.3914 and xxx.lanl.gov/abs/1011.3916

Provided by University of Birmingham