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ALICE, EYES FOCUSED ON THE PRIMORDIAL UNIVERSE

Interview with Federico Antinori, an INFN researcher and spokesperson of the experiment ALICE (A Large Ion Collider Experiment) at CERN.

In mid-May Quark Matter 2018 was held in Lido di Venezia, the 27th International Conference on ultra relativistic nucleus-nucleus collisions, which brought together hundreds of physicists from all over the world to discuss new developments in high-energy heavy ion physics. The conference focused on the fundamental understanding of matter in conditions of extreme high temperature and density. In such conditions, which were a feature of the very early universe, matter appears as a plasma of quarks and gluons, with quarks and gluons not confined within protons and neutrons of the atomic nucleus.

In Lido di Venezia, we met one of the leading scientists in this field, Federico Antinori, INFN researcher and spokesperson of ALICE (A Large Ion Collider Experiment), which is an international collaboration involving over 1500 people, counting physicists, engineers and technicians, from 37 countries around the world, and one of the four main experiments at the Large Hadron Collider (LHC) of CERN, dedicated in particular to studying quark gluon plasma. Federico Antinori has been part of this collaboration since the very beginning and he has covered a number of managerial positions over the years. In 2012, he was appointed coordinator of the physics of ALICE and while he was in charge the experiment produced several of its most important results. Since January 2017 he has been the head of the experiment, an appointment he will hold until December 2019.

ALICE is a unique experiment, its objectives are very different from the other LHC detectors, ATLAS, CMS and LHCb. These two experiments have been designed to study high energy proton-proton collisions, and to detect and study the Higgs boson, what are ALICE's main objectives? What was the experiment designed for?

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Yes, ALICE is rather different from the other Large Hadron Collider experiments, it is indeed designed with the specific aim of using heavy nuclei accelerated in the LHC in order to recreate in the laboratory an extreme state of matter, which we call the Quark Gluon Plasma (QGP). We think that QGP was present in the very first microseconds of life of the universe. So the experiment was designed with the specific aim of studying heavy nuclei collisions, which are very different from proton-proton collisions, there are many more particles that are produced and also we are interested in detecting as many as possible of these particles, so down to very low energies. Whereas, the other experiments have typically a minimal energy of a particle that they can detect, which is larger than for ALICE.

What do we know, so far, about the QGP, the extreme state of matter that characterised the very early universe, when there where extreme temperature and pressure conditions?
The quark gluon plasma is an extreme state of matter. The quarks and the gluons that in standard matter are always trapped, confined, inside other particles, such as protons and neutrons, become liberated. So we think this was actually the state in the very first microseconds of life of the universe. So, we have been able to measure very precise, specific and practical properties of the system. We know that QGP behaves very much like an almost perfect liquid: a liquid with very low viscosity. We have been able to measure how such a system is opaque to the passage of high energy particles and how it responds collectively to fluctuations in the initial geometry. We have also made a whole series of measurements on how ordinary particles, the particles that we measure every day in the laboratories, emerge from these quarks and gluons that form this primordial state.

ALICE has given precious insights on the similarities and differences between matter and anti-matter. What did you observe?
With collisions of heavy nuclei we can also go beyond just the study of the properties of the quark gluon plasma. We can use the QGP itself as a source of particles: as the quark gluon plasma expands and cools down, it can generate a very large range of masses of particles and we can use it to study the properties, for instance, of anti-nuclei or anti-hyper-nuclei, exotic nuclear states. For instance, we have measured the properties of the deuteron and of the anti-deuteron, a heavy isotope of hydrogen which has in its nucleus a proton and a neutron, and we have been able to use this source of particles to measure their masses to a level that was unprecedented in precision.

How do you evaluate your first year as ALICE spokesperson? What will the experiment be

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focussing on in the near future?

We are now very active both on the experimental and on the analysis floors. We are still collecting new data and, at the same time, we are analysing a large amount of data already taken. But we are also preparing for the future. On the medium term, we have a very important data taking coming up for the rest of this year, where we will collect our largest data set, our largest statistics sample of collision events ever. And for the coming years, we are preparing a very substantial upgrade of the apparatus of the experiment. We are going to change the inner part of the detector, the area that is closer to the collision; we are going to make the experiment much faster, in terms of the amount of data that it can collect and we are going to the high-luminosity era, that will allow us essentially to collect hundred times more statistics than what we have now. So we will be able to go to a really much more precise detail in the measurement of the properties of the quark gluon plasma. This is what we call the high-precision era in the study of the QGP.

Have unreleased results been presented during the conference?

The vast majority of the results that were presented at Quark Matter 2018 were new. The field of ultrarelativistic nuclear collisions is mainly dedicated to understanding how matter behaves in the extreme conditions of heating and compression that are reached in collisions of heavy nuclei accelerated at the high collider energies.

We know significantly more than two weeks ago on the production from the quark gluon plasma of all kinds of particle species, from photons to nuclei and hypernuclei. We have also made crucial progress in understanding how QGP effects depend on the size of the colliding system. In addition, major advances were reported on the theoretical front. We can certainly say that QM2018 has represented a notable jump for our field.

Going back to your personal experience, what does it mean to lead a collaboration of 1500 physicists coming from all over the world?

Leading such a large collaboration is certainly something for which university does not prepare us: this is not what we study when we study physics, but it is something very enriching. What you understand is how important diversity is, how crucial it is to have different people, from different cultures, different viewpoints and different approach to work. One revelation is how this is crucial to the success of the international collaborations. People are always challenged by a different point of view, so you can never relax into you own, you have always to be ready and able to explain things to other people and to incorporate other view points in the way you work. I think that if there were one

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aspect of our job that I would put forward, it would be this one: I believe this is a key aspect for the success of this experiment.

Once again, an Italian researcher has been appointed as spokesperson of one of the main LHC experiments. What does it mean according to you?

Well, I think that having once again an Italian nominated as responsible of one of the LHC experiments gives a clear message on the quality of the whole Italian high energy physics community. There is a lot of tradition in Italy, this is an area where we have very good schools and we continue to produce very good young scientists. And I think that this, in the end, is a recognition by the whole international community of our past, our present, and the perspective that we hold for the future of Italian physics research. ■