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A team of physicists and students from the CU Faculty of Mathematics and Physics working on the CERN´s ATLAS experiment received the Miloslav Petrusek Award for the presentation of the Charles University at a festive ceremony in the Carolinum on April 3. We have asked Doc. Rupert Leitner, who received the award on behalf of the team, to tell us about the search for Higgs boson.

You joined the ATLAS experiment in the early stages of its preparation and had an opportunity to follow its development since the very beginning. Could you tell us how international cooperation has changed in recent years?

We started to work on the ATLAS experiment with colleagues from the CU Faculty of Mathematics and Physics, the Institute of Physics of the Academy of Sciences of the Czech Republic and the Czech Technical University about twenty years ago. I had the unique opportunity to be part of the whole preparation of the experiment, its construction up to the acquisition of the fundamental physical results. I can well remember the enthusiasm when modelling the physical processes or manufacturing components of the ATLAS detector in our institutes and in the companies in the Czech Republic as well as the days we spent testing the detector´s components in local and foreign labs.

Our team currently focuses on ensuring the operation and upgrades of the ATLAS detectors´ components, particularly on analysing the acquired data on proton collisions in the LHC accelerator. Several of our colleagues have been directly involved in the measurements of the Higgs boson properties; others have been researching properties of the heaviest top quark, looking for rare ways of the decay of mesons with the bottom quark and measuring the dispersion of protons into small angles. The group of physicists and students researching the collisions of lead nucleus has earned a great international reputation.

International cooperation is a natural part of particle physics; after all, CERN was founded in 1954 to foster cooperation among European nations. It continuously compares the level of scientific research, education as well as standards of administrative efficiency. The LHC project is a specific example of streamlining the potential of the CERN member states and other countries all over the world with the aim of constructing the most powerful particle accelerator. In addition to its scientific importance it also represents an extremely interesting experiment in managing cooperation among thousands of scientists.

As you may know, two leaders of the ATLAS experiment, Peter Jenni and Fabiola Gianotti, have recently won a number of international awards. Both of them have always been extremely supportive of the involvement of the Czech institutions in the ATLAS project; they have highly valued cooperation with the Czech researchers, and they have received honours from our university for that. Doctor Peter Jenni received a Charles University medal in 2001 and Fabiola Gianotti was awarded a commemorative medal of the CU Faculty of Mathematics and Physics last year.

You have received the award for promoting the project in the media. What, in your view, is the biggest contribution of this type of scientific cooperation to the overall climate in the Czech science community and the Czech society as a whole?

The award was presented to the team of physicists and students from the CU Faculty of Mathematics and Physics working on the ATLAS experiment. Understandably enough, I am extremely happy that our team, together with our colleagues from the Institute of Physics of the Academy of Sciences of the Czech Republic and the Czech Technical University in Prague and the Palacký University Olomouc, has participated in such a major scientific discovery. On top of the indisputable scientific contribution of CERN´s experiments, it was mainly thanks to the dedicated work of my colleagues in recent years that we have managed to raise public awareness of particle physics and of such key terms as ATLAS, CERN, LHC and Higgs boson in this country. Fundamental research, the immediate practical usefulness of which is unpredictable and might be quite distant, has proved to be interesting for the general public, who positively perceives our "being there". However, only a fundamental research that stands whatever quality tests and brings new knowledge about the world can be easily defended and justified.

Knowledge and skills gained by academics and students during their work on such an outstanding project is invaluable for Charles University. Dozens of Czech teachers, too, have been acquainted with CERN. Being in touch with top-level contemporary science is an extraordinary experience for them.

For young people particle physics is a textbook illustration of science, which represents a challenge, an opportunity to explore new mysteries as well as an opportunity for a meaningful fulfilment of life.

Recent reports on the progress in search for Higgs boson have attracted a lot of attention. What are the latest results?

In July of 2012 teams of physicists from the ATLAS and CMS experiments in the European Laboratory for Particle Physics CERN announced the discovery of a new boson with a mass of 125 GeV. This discovery came as a result of exploring the products of proton collisions in the LHC accelerator.

The amount of experimental data gathered between July 2012 and the shutdown of the LHC more than doubled. Apart from confirming the existence of a new particle the research focused on detailed studies of its properties aimed at revealing whether this was indeed the long-sought Higgs boson or not. Its quantum numbers have been exactly determined in theory: it is supposed to be an elementary particle with no spin; the simplest version of the theory says only one electrically neutral Higgs boson with a +parity should exist.

Even though the theory cannot predict the Higgs boson mass, as soon as the mass is experimentally measured, the theory precisely predicts how often and into which particles the Higgs boson should decay. The latest results announced by the two experiments at the March 2013 conferences show that the measurements of the observed decay modes of a new boson and the quantum numbers correspond to the theoretical predictions and that the new boson is most likely THE Higgs boson.

The decays of the new particle into a pair of Z bosons and Gamma quanta have been observed; there has also been evidence of the particle decaying into a pair of W bosons and a pair of the heaviest tau leptons. All of these are decays of an electrically neutral particle. The value of the mass will be determined by measuring the momentum and the energy of the decay products and by making use of the relativistic laws of conservation of energy and momentum. The existence of the decay into a pair of Gamma quanta indicates that the new boson has a spin-0; the exotic option of a spin-2 also remains in play. By analysing the decays into the pair of Z bosons it is also possible to determine internal parity, a measurement that prefers a particle with zero spin and +parity consistent with the Higgs boson theory.

Current measurements are based on a few dozens of observations of decays into a pair of Z bosons and a thousand of decays into a pair of Gamma. Much more data still have to be amassed in order to fully confirm whether it is specifically a Higgs boson or one of more Higgs bosons and to confirm other decay modes and further analyse its properties. That is why the LHC accelerator and the detectors are now being upgraded in order to double the energy and increase the intensity of proton collisions.