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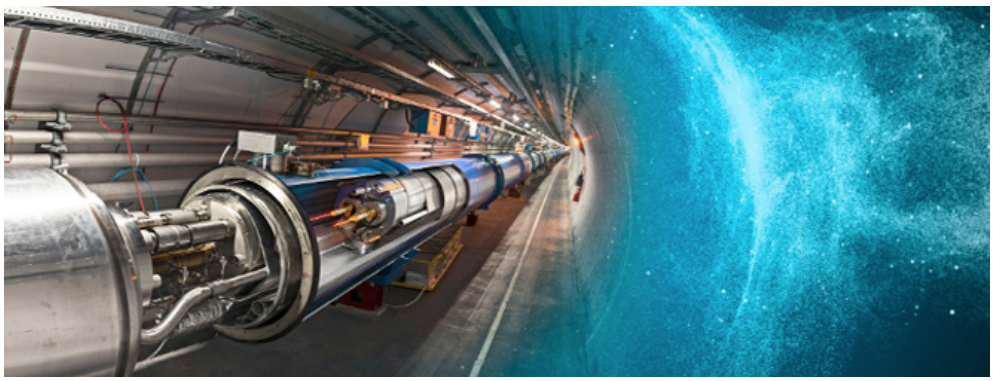
New discoveries await scientists

8 April 2015



As the world's most powerful particle accelerator, the Large Hadron Collider (LHC) at the European Organization of Nuclear Research (CERN) in Geneva, Switzerland, re-started over the weekend physicists from the University of the Witwatersrand in Johannesburg are ready to further explore the frontiers of science that led to the discovery of the Higgs boson particle in 2012.

The circulation beams rebooted on Sunday morning, 5 April 2015 – a major milestone towards resuming proton-to-proton collisions and delivering protons at a new energy frontier before the summer in the northern hemisphere. "The return of beams to the LHC rewards a lot of intense, hard work from many teams of people," said Head of CERN's Beam Department, Paul Collier. "It is very satisfying for our operators to be back in the driver's seat, with what is effectively a new accelerator to bring on-stream, carefully, step-by-step."

"Operating accelerators for the benefit of the physics community is what CERN is here for," said CERN Director General, Professor Rolf-Dieter Heuer.

The historic observation three years ago of the Higgs boson, a puzzle piece in the Standard Model of Particle Physics, opened up possibilities of more exotic particles waiting to be discovered.

"There are many questions left unanswered in the Universe, some of which we hope to answer when the Large Hadron Collider (LHC) is once again fully operational," says Professor Bruce Mellado from the Wits School of Physics.

An expert on the Higgs boson, Mellado – who leads the University's involvement in the Atlas experiment at CERN - was recently appointed co-convener in the Higgs Cross-section Group at CERN that puts together the work of more than 100 theorists and experimentalists, and oversees seven subgroups that are setting up standards for the study of the properties of the Higgs boson with the data that the Large Hadron Collider will provide. Mellado has also been made a member of the Large Hadron Electron Collider (LHeC) Coordination Group – a new proposed R12-billion facility to be constructed.

Wits and the ATLAS experiment

Mellado and colleagues in the High Energy Physics (HEP) group in the Wits School of Physics are investigating peculiarities seen in the Higgs boson results made publicly available by the ATLAS experiment.

The possible explanations to these peculiarities range from a set of random statistical fluctuations, which may disappear with more data, to a much more interesting possibility of the observation in laboratory conditions of dark matter particles. This would signify a

finding as important as that of the Higgs boson.

HEP will be quite active in this investigation and crucial support from the Department of Science and Technology, through the SA-CERN programme and bursaries, as well as University contributions will play a critical role in this endeavour. Professor Alan Cornell, a high-energy particle physics theorist from the Mandelstam Institute for Theoretical Physics at Wits, collaborates with experimentalists of the HEP group to devise new scenarios unexplored before. Another new member to the HEP group, Dr Deepak Kar from the University of Glasgow, will bring a complimentary dimension to the group through his knowledge and experience.

Since the start of 2013, the Wits-ATLAS group has submitted and/or published over 60 proceedings and research papers. Students Harshna Jivan, Mitchell Cox and Robert Reed have received five prizes in the same period of time. The group has been honoured with the First Time Inventor Award (2014) and the Most Cited Researcher Award (2015) by the University.

Wits played an active role during shutdown

The HEP group was very active during the shutdown of the LHC since 2013 – in order to prepare the collider for almost double the previous collision energies. Members have designed and locally produced High Voltage, LED and ADC electronic boards that are used in a mobile integrity-checking system that validates and consolidates the electronics on the ATLAS detector at the LHC. These boards along with custom software, also developed by the group, used a new design, called Prometeo, which is intended for the upgrade of the LHC expected in the year 2022.

Dealing with data explosion and development of low-cost computers for South Africa

Storing the large amount of data – in the order of a few Petabytes per second – that the LHC is expected to generate in the near future, is a major concern to physicists. In response, the HEP group also initiated the development of software tools that integrate the new hardware into the ATLAS detector control system, and the group is developing a novel way to deal with the data explosion by processing the data, in real time, using energy efficient and cost effective processors found in mobile phone devices.

These high-end electronics are being designed and developed in the new High-throughput Electronics Laboratory (HTEL) in the Wits School of Physics. The lab was inaugurated in November last year by the Wits Vice-chancellor and Principal, Professor Adam Habib, the Dean of the Faculty of Science, Professor Helder Marques, and Head of the School of Physics, Professor John Carter.

As a spinoff of this high-end electronics research, the HTEL also houses the design of low-cost computers for schools in Gauteng. The Technology Innovation Agency has awarded the HTEL with a grant to launch a pilot project at selected schools to study and develop these devices to best suit the education environment

Wits' efforts with ALICE

The re-start of the LHC at the new energy frontier and with greater intensity also brings reinvigorated excitement for the ALICE experiment at the LHC. Professor Zeblon Vilakazi, Deputy Vice-Chancellor: Research, leads Wits' efforts at the ALICE experiment. The ALICE experiment seeks to investigate the state of matter that excited a millionth of a second after the Big Bang - known as the quark gluon plasma — a soup of matter particles that cooled down to form atomic nuclei that we observe today.

Synergies with nuclear physics and material sciences

Professor Elias Sideras-Haddad leads synergistic activities between high-energy physics and the HTEL with nuclear physics and material sciences. At the forefront of these investigations lies a unique set of South African accelerator-based facilities that allow scientists to reproduce the challenging conditions of radiation at the LHC. In particular, radiation damage of ATLAS detector components is studied using several techniques developed for the material sciences.