

The Research Group
Elementary Particle Physics

has the honour to invite you to the public defence of the PhD thesis of

Jarne DE CLERCQ

to obtain the degree of Doctor of Sciences

Title of the PhD thesis:

The Upgraded Outer Tracker for the CMS Detector at the High Luminosity LHC and Search for Composite Standard Model Dark Matter with CMS at the LHC

Promotor:

Prof. Dr. Steven Lowette

The defence will take place on

Tuesday January 28 2020 at 16h00
in Auditorium **D.2.01 (Promotiezaal)** at the
Campus Etterbeek of the Vrije Universiteit
Brussel, Pleinlaan 2 - 1050 Elsene, and will
be followed by a reception.

Members of the jury

Prof. Dr. Jorgen D'Hondt (VUB, chairman)
Prof. Dr. Krijn De Vries (VUB, secretary)
Prof. Dr. ir. G. Vandersteen (VUB)
Prof. Dr. Pascal Vanlaer (ULB)
Prof. Dr. Nadia Pastrone (INFN Torino)

Curriculum vitae

Jarne De Clercq graduated in 2015 with greatest distinction with a Master of Science in physics and astronomy at the University of Ghent. Next, he embarked as a PhD student in elementary particle physics at the Vrije Universiteit Brussel. Within the context of the CMS experiment, he worked on two big projects: a search for a dark matter candidate in the data of the CMS experiment, and the development of a testsystem and testing of prototypes for the upgrade of the CMS tracking detector.

Abstract of the PhD research

The Standard Model of particle physics describes matter and its interaction at the most fundamental level. Measurements at high energy physics experiments are described to high accuracy by the Standard Model, but astronomical and cosmological observations hint at the need for physics beyond the Standard Model. An example of such an extension is dark matter.

The Large Hadron Collider (LHC) at CERN is the most powerful particle accelerator ever built. The Compact Muon Solenoid (CMS) experiment, which is located at one of the LHC interaction points, is an ideal tool to test the Standard Model as well as to search for new physics. The work which is presented here consists of two parts: a search for 'sexaquarks' with the data from the CMS experiment and the upgrade of the CMS tracker detector for operation at the High Luminosity LHC.

Sexaquarks are put forward as a new type of matter with the potential of explaining the nature of dark matter. In this research, signals of anti-sexaquarks, produced in proton collisions, are sought for. This is done by looking for anti-sexaquarks annihilating on neutrons in material inside the CMS detector. This annihilation process can eventually result in charged particles which are reconstructable with the CMS tracker. The reconstruction gives access to the mass of the sexaquarks as well as its interactionpoint.

The current CMS tracker will be in operation until 2023 after which a new tracker will be needed by 2026 for data-taking at the upgraded LHC, the so-called High Luminosity LHC (HL-LHC). This new tracker will enable CMS to collect high quality physics data in the harsh environment of the HL-LHC. The new tracker has to cope with higher radiation and has to provide input to the trigger system of CMS. This system decides if the full CMS detector will be read out. CMS will accomplish this by using a unique detector module design based on silicon sensor technology. In the end, thousands of these modules will be used in the CMS tracker detector. These modules contain several readout chips which process the signal before sending it to the trigger system or the central data acquisition. The research in this thesis describes the contribution to a test system for testing prototype chips, assembled electronics components and prototypes of detector modules. The test system is then used for chip testing at high radiation dose, evaluating module operation in test beams and investigating the intercommunication between different chip types.