

The CMS (Compact Muon Solenoid) experiment is one of four large experiments operating at the Large Hadron Collider (LHC) at the European Organization for Nuclear Research - CERN laboratory located near Geneva, Switzerland. The Large Hadron Collider accelerator, one of the largest research facilities on Earth, is located in a circular underground tunnel 27 km long. Inside the tunnel there are pipes in which, at a speed close to the speed of light, packages of protons circulate the LHC. Packages of proton collide with each other at four points. Four detectors: ATLAS, CMS, LHCb and ALICE, are placed around those points in order to record all particles that are formed as a result of the collisions. The LHC was launched in 2008, and its schedule is divided into stages (Runs) between which there are scheduled breaks designed to increase the performance of the collider and experiments, in particular the number of proton-proton collisions provided by the accelerator. The most important physical result of the CMS experiment to date is the discovery (together with the ATLAS experiment) of the Higgs particle that has been sought for half a century. This discovery contributes to the understanding of the how fundamental objects acquire mass.

In the years 2022 – 2024, there will be a third stage (Run 3) of the collider operation, followed by a three-year break, intended to significantly increase the performance of the LHC. In 2027, the fourth stage (Run 4) of the LHC operation is scheduled to begin. The Project is part of the program to increase the research potential of the CMS experiment and prepare it for operation after 2027. The aim of the Project is to develop a part of the CMS detection system called the trigger. The trigger is the first stage of processing the data recorded by the CMS detector. The amount of this data is so large that it is impossible to record it on computer disks and a multi-stage selection is necessary. Collisions at the LHC occur at a frequency of 40 MHz. During the Run 3 of LHC operation only 100 kHz of data will be accepted on the first stage of the CMS trigger system and submitted for further selection. In the end, only about 1000 Hz of data will be saved on computer disks. CMS detector upgrade for the Run 4 assumes 7.5 fold increase of the data rate accepted by the trigger: to 750 kHz at the first stage, and to 7.5 kHz at the last one. The greater amount of stored data allows the study of phenomena that have small probability to occur.

This proposal is intended to finance the development of the algorithms used in the first stage of the trigger. The project will be realized within the Warsaw CMS experiment group - a team of physicists and engineers who, have been responsible for the trigger subsystem dedicated to the detection of muons in proton collisions at the LHC. The existing algorithms, developed so far by the Warsaw group do not meet the requirements set by the Run 4 of the LHC. The new algorithms will use the latest data analysis methods - the so-called machine learning, and profit from additional input data that will be available thanks to the expansion of other elements of the first stage of the trigger system.

The proposed research is an important step that allows continuation of data collection by the CMS experiment with the best selectivity and efficiency in the more stringent research rigor set by the modernized LHC accelerator. The developed algorithms will be directly used in all physical channels with muons in the final state. This is of particular importance for the continuation of analyses of properties of the Higgs boson. The proposed research allows Polish physicists and electronics engineers to participate in these pioneering discoveries and underlines the significant contribution of Polish science to international research cooperation.