The most important direction of research currently being carried out in the field of experimental high-energy physics is either the confirmation of the Standard Model or, on the contrary, the search for processes that go beyond it. This applies both to the search for Dark Matter and to new states explaining the observed deviations from the current theory.

Physical analyses conducted by experiments operating at the Large Hadron Collider (LHC) have not yet yielded results in this field, and the only new state discovered at the LHC is the Higgs boson, which confirmed the Standard Model. However, no new particles predicted by, for example, supersymmetric models or phenomena that are significantly inconsistent with theoretical predictions have been observed, and there are no confirmed candidates for Dark Matter. On the other hand, a whole range of results have been observed related to heavy quarks that do not fully agree with predictions, such as anomalies in processes with the preservation of the lepton number, or inconsistencies in the probabilities of decays. The future of the search for New Physics may focus in the next two decades on experiments with hadron accelerators with high energies and high luminosity, or on indirect measurements.

In each case, the heart of the experiment are tracking detectors adapted to work in extreme radiation fields. Detectors of this type must be characterized by high granulation (i.e. the number of active reading channels per unit area) and high signal formation rate. These features have sensors based on semiconductor technologies, and silicon sensors are mainly used. However, these are structures in which there is a significant change in physical properties as a function of the fluence (this can be roughly understood as the sum of all particles that pass through the detector surface throughout the experiment). In addition, in the new experiments, we expect up to 200 elementary interactions per beam intersection, which will significantly reduce the quality of the track's reconstruction procedure. One of the proposed solutions is to combine the geometric track of the particle with time, with the resolution of such a measurement being at least 30 – 40 ps. This type of approach is called 4D reconstruction and is currently being intensively studied by major scientific groups related to experimental high-energy physics. Currently, the leading technologies that are being studied for their possible use in next-generation experiments are: monolithic sensors, ultra-fast LGAD structures with internal reinforcement, 3D pixel sensors and 3D integrated structures. The main factor that will determine the usefulness of a given technology is resistance to radiation damage and the degradation of key macroscopic parameters of sensors caused by them.

The presented project concerns the work of the AGH UST Group conducted jointly with international centers (CERN, Great Britain, United States) on research on new semiconductor technologies that will be used in new physics experiments (Hi-Lumi LHC, FCC). The main idea is to implement a synergistic cycle of designing and testing silicon structures using simulation studies (TCAD), production of prototype sensors, irradiation under controlled conditions and measurements using the induced current technique (TCT). The obtained measurement results can then be used to verify and modify simulation models. Sensor tests will be carried out at AGH University of Science and Technology in Krakow laboratory with the TCT set-up. The group also has a license for the programs for simulation.