

The Standard Model (SM) of particle physics has been extremely successful in describing all observed phenomena of the micro-world, including properties of the last unconfirmed elementary particle predicted by the SM – the Higgs boson discovered in 2012 at CERN. Still, there are many burning questions left unanswered by the SM, as for example: what is the origin of the pattern of masses of elementary particles, why three elementary interactions, electro-weak and strong, are having such particular symmetries, and is gravity another type of elementary interactions?

This project proposes yet another way of addressing some of such questions by developing and applying novel techniques of selection and analysis of the data collected at the Large Hadron Collider (LHC) and future high energy colliders. This will allow for in-depth studies of interactions of particles involving high energy photon-photon fusion. Such $\gamma\gamma$ processes provide unique insights into the nature of elementary interactions, in a very complementary way to the standard studies of quark and gluon interactions.

Measurements of two-photon processes will be very challenging at the planned high luminosity phase of LHC due to a very large event pileup, therefore special efforts have to be made, as proposed here, to mitigate this problem by use of planned picosecond resolution timing detectors, for example. On the other hand, the photon-photon studies will be particularly powerful at the future electron-hadron colliders, such as the Large Hadron electron Collider (LHeC) and the Future Circular Collider (FCC). Within this project, its Research Team will significantly contribute to developments of the experimental programs at the LHeC and FCC, as well as to evaluations of their scientific potential, also in view of the update of European Strategy in Particle Physics in 2027.

Particle physicists, using very large and costly research facilities such as high energy colliders, should make all the effort to bring out the best possible science. Therefore, it is also their fundamental obligation to explore and utilize all viable and scientifically significant research avenues.