The goal of the proposed project is active particiation in the precision measurements of the Standard Model bosons properties: W, Z, Higgs boson, in particular in the decay to the tau lepton pairs, which will be carried by the LHC experiments with data collected during so called Run II (years 2015-2018) in the proton-proton collision with centre of mass energy of 13 TeV. The experimental analysis which are of interest for this project are measurements of differential cross-sections, in particular in the so called vector-boson fusion production where Higgs boson (or longitudinal state of the inermediate electroweak boson) is accompanied by two jets, and to measure Higgs boson quantum numbers (CP states) in observation of the transverse spin correlations of the tau lepton decay products. Such studies require availability of the respective theoretical predictions and tools for modeling signal and background processes including spin effects and realistic obserwability potential of the detectors. Theoretical and experimental aspects necessary for this goal are to be pursued.

Proposed project is prepared by the research group composed of two experienced researchers, one young researcher (with PhD), doctoral students and small number of diploma students of physics or computing science. One of the experienced researchers (project leader) since years is working with one of the experimental group at LHC (ATLAS experiment) and has significant experience and knowledge concerning physics of the Higgs boson and experimental potential for analyses with tau leptons in the final state. Second senior researcher is an expert in the area of constructing Monte Carlo generators and phenomenological observables for the physics at lepton and hadron colliders. The proposed tasks represent very constructive collaborative effort for preparing experimental and theoretical aspects of the measurements and in the form which is directly suitable for applications in the experimental analysis.

In the scope of proposed grant we plan development of the theoretical formalisms for precision measurements of W and Z boson properties and Higgs boson CP state. We will use modern machine learning algorithms and multi-variate analysis to improve precision and applicability of the measurement observables. Finally we will participate in the data analysis of ATLAS experiment at LHC, directly addapting proposed algorithms and mearement observables to the experimental reality of analyses.

The goal of large experimental infrastructure, such as accelerator LHC at CERN laboratory and also future accelerators of high energy physics, is to allow for performing studies leading to break-through discoveries in our understanding of fundamental constituents of the matter and their interations. Discoveries in the area of high energy physics might lead to understanding of fundamental problems in the evolution of the Universe (asymmetry between matter and anti-matter, dark matter, dark energy, etc.) and the same might have important impact on the further research programme of astrophysics and cosmology.

Results, which we plan to achieve in the scope of research tasks proposed in this grant will be crucial for confirmation of the properties of the Higgs sector in the Standard Model, CP state of the Higgs boson and properties of Z and W (multi) bosons interactions, and the same might turn out very important for experimental observation of the New Physics phenomena at LHC energies or future akcelerators. Recently the Machine Learning techniques are becoming irreplaceable in the experimental analysis of LHC data, and with this project we plan to push it forward also in defining theoretical observables proposed for experimental measurements. This direction, which will lead to more scientific collaborations between HEP and computing science experts in the local community in Cracow might turn out to be very fruitfull in the future.