Another success in understanding the Higgs boson: coupling to bottom quarks observed

A key property of the Higgs boson, the elementary particle discovered in 2012, has been observed at the CMS experiment at the CERN LHC: the decay into further elementary particles, the bottom quarks. Physicists at the Institute for Experimental Particle Physics at KIT contributed with their measurements to this result, which represents another confirmation of a central prediction of the standard model of particle physics. It follows the observations of the Higgs boson‘s interaction with top quarks and tau leptons, which has recently been achieved with leading contributions by KIT physicists.

The Higgs boson, which has been discovered in 2012 at the LHC, has a unique role in the standard model of particle physics, which describes the known elementary particles and their fundamental interactions. The Higgs boson is closely related to the mechanism that generates the masses of the particles, and a precise understanding of its properties is one of the major goals of the LHC physics programme. A central prediction of the standard model describes the characteristic interaction (``coupling‘‘) of the Higgs boson with the matter particles, the fermions: the coupling strength is expected to be proportional to the fermion mass. The coupling to the bottom quark is particularly interesting, because it is the heaviest fermion for which a decay of the Higgs boson into a fermion-antifermion pair is possible. A measurement of the rate of the decay provides access to the coupling strength and allows verification of the standard model prediction. This extremely rare process has now been observed for the first time by the CMS experiment; a similar result has been achieved by the ATLAS experiment. The result has been presented on August 28, 2018 at a seminar at CERN and will be published in the journal Physical Review Letters.

The measurement has been performed using data from approximately 4 million billion proton-proton collisions at centre-of-mass energies of 7, 8, and 13 teraelectronvolts, which have been collected since 2011. A candidate of a single collision in which a Higgs boson decays into a bottom quark-antiquark pair is shown in Fig. 1. The huge amount of data is necessary in order to identify the tiny signal above an overwhelming background of other processes, which look very similar in the detector but occur much more frequently, and to exclude a mere statistical fluctuation. For the same reason, the results of several measurements have been combined, which target different production processes of the Higgs boson. An important contribution stems from events in which a Higgs boson is produced together with a top quark-antiquark pair. KIT physicists of the group of Prof. Husemann had a leading role in the analysis of these events.

The observation of the coupling of the Higgs boson to bottom quarks marks another important milestone in the understanding of the Higgs boson. It follows the recent observations of the Higgs boson coupling to top quarks and tau leptons, to which KIT scientists of the ETP had a leading contribution. With this, the couplings of the Higgs boson to the three heaviest fermions have been observed. The measured coupling strengths are consistent with the prediction of the standard model, which represents a crucial validation of the theory. However, the current precision of the measurement still allows for the presence of effects from new physics beyond the standard model. In the coming years, more data will be analysed in order to further increase the precision and discover possible new, unknown properties of the Higgs boson.

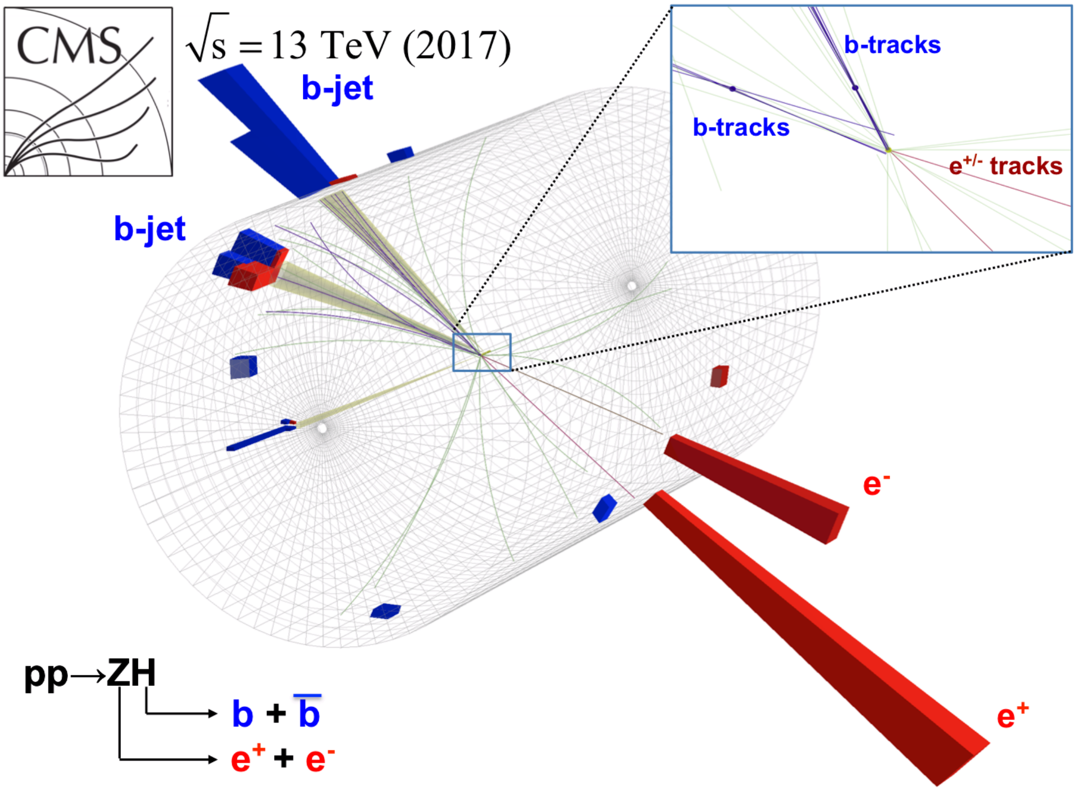

Fig. 1 Visualisation of the detector signals of a candidate of a collision event in which a Higgs boson decays into a bottom quark-antiquark pair.