The proton, one of the basic constituents of atoms, was discovered around 1920. Its structure has been intensively studied since that time mainly with the help of proton-proton collision experiments. Main progress has started when corresponding experiments at the world's first hadron collider ISR at CERN which ran from 1971 to 1984 were performed. The understanding of the structure and interactions of this subatomic particle protons has been, however, rather incomplete. Only some very general models have been available especially in the case of higher collision energies when very different kinds of collisions have existed. Some very simplifying assumptions of unclear physical meaning have been then involved in models concerning elastic processes. The influence of these assumptions on physical interpretation has started to be studied and some progress has been made when the eikonal model has been proposed, i.e., the dependence of elastic collisions on corresponding impact parameter values has been taken into account from the beginning. However, even if some new results have been obtained many unanswered questions have remained. For example, the collision process has been denoted generally as probabilistic but corresponding probabilities have not been sufficiently defined and determined. The given thesis contains, therefore, summary of different contemporary descriptions of elastic hadron collisions concerning the influence of impact parameter and the discussion of consequences and justification of some important assumptions. The eikonal model has been generalized and demonstrated on experimental data at 53 GeV and then applied also to newly obtained data at 8 TeV. Consequently, the contemporary TOTEM experiment at the LHC accelerator at CERN devoted to measurement of elastic pp scattering and diffractive processes at the highest ever reached energies has been described. In the given thesis several important open problems blocking the progress in the given area of research have been identified. A new probabilistic model of particle collisions has been then shortly described; the dependence of elastic collisions on impact parameter having been systematically taken into account in analyses of corresponding experimental data. It has been demonstrated that with the help of it deeper understanding of characteristics and interactions of fundamental particles might be obtained.