Main research in the field of plasma physics and thermonuclear power engineering began in the 1950s. The driving forces were: the crucial discoveries in the field of nuclear physics, the significant technological jump, the constantly growing request for energy and potential use in the military applications. This led, for example, to the construction of the first nuclear reactors. Despite important achievements of last century, there is still a search for the new, more perfect sources of energy. In the nature, the Sun is such a source. The Sun is a giant thermonuclear reactor, which produces energy as a result of the fusion of light nuclei. The problem of constructing a device that would work in a similar way as the Sun has become one of the most important problems of modern physics and engineering. In the 20th century, four main types of devices were developed, considered to be future fusion energy reactors: tokamaks, stellarators, laser microfusion laboratories, and plasma-focus devices. Currently, the latter are mainly used in basic research in the field of plasma physics and are becoming more and more popular as efficient sources of radiation.

The PF-24 plasma-focus device is an example of a dynamic, non-cylindrical z-pinch type plasma generator with an experimental chamber of the Mather type. It operates in the Institute of Nuclear Physics Polish Academy of Sciences in Cracow. The PF-24 device generates plasma in a working gas in a form of thin, radially symmetrical current sheet, created as a result of an electric breakdown over the surface of insulator between coaxial electrodes. The generated plasma sheet rapidly detaches itself from the insulator and is accelerated along the anode with the Ampere's force. At the end of anode, the sheet is compressed in the direction of the z axis (radial direction); so called plasma pinch is created. The plasma pinch is a relatively short lived (up to about 100 ns) and small object (a few cubic centimeters in volume) in the shape of a funnel or a column. It is also a source of various type of radiation: electromagnetic radiation, ions, electrons, plasma waves and plasma jets, and neutrons (when light gas is used, for example deuterium).

The physical processes associated with the discharges in the plasma-focus device are still not fully investigated and understood. One of such process is the plasma radiative compression. The plasma radiative compression is the phenomenon in which the plasma density and emission of X-ray radiation should increase significantly, while the volume of plasma and its temperature should decrease significantly. This effect should theoretically lead to a very high plasma concentrations (up to 10^{28} particles/cm^3), and to a very small pinch radius (down to 10^{-6} cm). However, the achievement of such large compressions has not been proven experimentally. In fact, is believed that the plasma radiative compression is sufficiently studied only the case of micro-pinch discharges (a sub-type of z-pinch discharge). In the case of other z-pinch devices, the results, both theoretically and experimentally, are controversial, inconclusive and insufficient. Hence, the proposed project focuses on the verification of the phenomenon of plasma radiative compression.

The project involves the investigation of plasma radiative compression using the combined experimental and theoretical methods. The experiments will be performed using the PF-24 device and three diagnostic systems: Rogowski coil, magnetic probe and ultra-fast 4-frame plasma imaging system in Vacuum Ultra Violet and Soft X-ray. The discharges will be carried out in deuterium, noble gases and mixtures of deuterium and noble gases. The theoretical computations will be carried out using the 5-phase Lee model code. The experimental and the theoretical methods will be coupled by using a special procedure of fitting the simulated current traces to the measured ones. The results will be complementary providing a set of parameters describing the plasma and discharge as a function of time.

The project has the character of basic research on the hot and dense electron-ion plasma generated in the z-pinch devices. The obtained parameters will allow: verification of the phenomenon of plasma radiative compression and determination of the conditions under which the radiative compression may develop (and my not develop) during discharge. The implementation of the project will explain the controversies related to phenomenon being studied and will enable acquiring of well-tested knowledge. These investigations are also important for better understanding of other effects associated with the z-pinch discharge, for example, the phenomenon of fusion neutron production and emission. In addition, the results of this project might be used to further development of the Lee model code. Confirmation of increased radiation emission may allow a better use of plasma-focus devices as strong, short-pulsed sources of radiation. The increased radiation can be used in tests of materials and their properties, dynamic, non-destructive quality control, X-ray microlithography and micromachining and in other potential applications.