Nowadays, thermonuclear fusion brings hope to meet the needs of the growing demand for energy in a sustainable, safe and environmentally friendly manner. Studies on fusion energetics have been conducted in Europe and around the world for many decades. Huge expectations are placed onto the largest experimental fusion-based reactor - ITER (Latin: *road*), which is currently under construction in France. This reactor is based on the concept of magnetic plasma confinement, called a tokamak. The aim of this international development is to demonstrate nuclear fusion as a viable and sustainable energy source.

Despite many years of efforts by scientists in the physics of tokamak plasma, many issues remain unresolved and require deeper understanding. Already at the initial stage of construction of the first experimental reactor, it became obvious that the future of these devices largely depends on solving the problems associated with the first wall of the reactor chamber. Plasma, as a result of interaction with the construction material, can erode the material, which can then settle elsewhere in the vacuum chamber, but also penetrate the plasma. Radiation from impurities such as carbon or tungsten (materials for plasma facing components of current tokamaks and stellarators) is one of the major pathways for power loss by fusion plasma. Moreover, the processes of diffusion and non-local transport associated with the development of various types of magnetohydrodynamic (MHD) instabilities in plasma also contribute to energy loss, whereas the interaction between impurity transport and MHD activity can lead to the impurities accumulation and ultimately to the disruption of the fusion reaction. Studying runaway electron generation and disruption mitigation are among the key topics to be understood and solved in order to secure a safe operation of ITER.

Due to the fact that the emission of soft X-rays in the tokamak plasma is related to the presence of impurities, it is the selection of appropriate diagnostics that is important, as it is one of the main sources of obtaining reliable information about physical processes taking place in the plasma. Various processes involving electrons interacting with ions or an external magnetic field are also sources of X-rays. Therefore, it is necessary to measure the radiation distribution and develop diagnostics that provide information about the spatial and spectral distribution of plasma emissions. In turn, the problem of degradation of conventional X-ray detectors in future fusion devices is inevitable due to the anticipated extreme fluxes of ionizing radiation. Therefore, the development of new diagnostic technologies towards future fusion reactors deserves special attention and is one of the goals of the proposed research. The huge size of plasma structures must be properly imaged, therefore a detector intended for X-ray diagnostics must have both a large detection surface and good spatial resolution of the recorded radiation quanta.

The scientific objective of the proposed project is (i) to study the 3D phenomena of the tokamak plasma, best observed with toroidal cameras, from the ITER/DEMO perspective (future first demonstration power station); and to this end (ii) to develop an advanced imaging diagnostics that will be able to perform global imaging of soft X-ray radiation in the photon counting mode (also determining their energy), using a detector based on a Gas Electron Multiplier. The proposed research relates more than just standard soft X-ray tomography, as the spectral resolution information brings us step closer to tracking impurities of both high Z and light impurities. An important aspect of the proposed project is the ability to perform 3D plasma tomography, which is a feature far beyond the capabilities of conventional tomography. This itself provides a unique opportunity to detect and study toroidal anisotropy, which so far has hardly been investigated due to the non-axisymmetry of the plasma.

The project involves interdisciplinary research using modern methods and large international experimental devices. During the implementation, attempts will be made to use the developed diagnostic tool at the COMPASS-U tokamak (located in Prague, Czech Republic) in order to start research using soft X-ray imaging techniques, and among the others to provide information on the magnetic axis (in a limited number of cases), the shape of the plasma, issues that have not yet been fully explored. This development would complement existing efforts to control plasma shape using traditional magnetic measurements. The project offers an opportunity that the study of anisotropic radiation, triggered, for example, by magnetic reconnection or mass gas injection, will allow to increase knowledge and provide the community with an effective experimental tool to understand and study such phenomena as the generation of runaway electrons, spatial location and speed of magnetic reconnections, controlling the shape of the plasma and monitoring plasma contamination along with the activity of MHD.