One of the greatest scientific puzzles is how the Universe is created. After a century of intensive research, it has come to our conclusion that our world consists of indivisible element particles that interact with the help of force exchange particles. The theory of how this works is called the Standard Model and it has been tested and verified very successfully in experiments. Nevertheless, we know that it does not give the whole picture: it merely describes the visible matter in the Universe. From studies of the rotations of galaxies and the expansion of the Universe, it has been found that only about 4-5% of the Universe consists of visible matter. The rest consists of so-called dark energy and dark matter. However, no traces of these phenomena have been found in the experiments carried out. Is it because dark matter and energy do not exist, and that we have thus misunderstood something fundamental about the Universe? Or is it because we have been looking for the wrong places?

In this project I intend to look for dark matter making use of high precision measurements of the decay of the Positronium atom, a particular element form of a particle and its counter-partner or anti-particle. Many experiments are based on the hypothesis that dark particles are so heavy that they have so far avoided being detected. By increasing the energy in the particle accelerators, the high-energy limit has been fine-tuned, while the precision limit is instead investigated. The basic hypothesis is that dark particles can certainly be as light as visible particles, but that they have not been detected because the probability that they interact with visible matter is so extremely small. Modern methods allow greater precision and thus new opportunities to find the needle in the haystack that is dark matter. Experimental facilities such as J-PET at the Jagiellonian University, allow for this type of research by providing a perfect setup where to study the invisible decays of Positronium.

The J-PET is a novel, total-body Positron-Electron Tomograph (PET) scanner, a largely and high precise medical imaging tool, based on the plastic scintillators. In the case of the J-PET at the Jagiellonian University, a novel PET scanner technology has been developed to have a cost-effective whole-body PET, compatibility with Magnetic Resonance Imaging (MR) and Computed Tomography (CT) technologies, and excellent timing capabilities among others. The J-PET setup can be used in a broad scope of interdisciplinary investigation, e.g. medical imaging, fundamental symmetry test and quantum entanglement studies with o-Ps, etc. For these reasons, the Jagiellonian University, and the JPET detector represent a unique possibility to perform searches of DM candidates.The results could provide the first evidence of the existence of a new type of matter connected to the DM component of our Universe, the largest part of our rich and complex home.