Many physicists believe that physics of elementary particles and interactions is at an impasse. Although the Higgs particle was discovered, which confirmed the Standard Model prediction, but there are many questions without answer. E.g. observed in the Universe asymmetries between matter and antimatter as well as between matter and relic microwave radiation cannot be explained by processes included in the Standard Model. Next, new particles, which existence was predicted by the Super-Symmetric Models, have not been discovered. We do not know what could be Dark Matter or Dark Energy. No theoretical model of particles and interactions, except for the phenomenological Standard Model, was experimentally confirmed. There is great hope, that precise measurements of properties of elementary particles are able to dig deeper in the nature of fundamental interactions and can help us to get out of that impasse.

For particles, atoms and molecules, which ground state in not degenerated, a non-zero value of the electric dipole moment (EDM) is an evidence of parity $\mathcal{P}$ and time reversal $\mathcal{T}$ violation, thus also of violation of combined $\mathcal{CP}$ symmetry, where $\mathcal{C}$ is a charge conjugation operation changing particle to anti-particle. The EDM for such particles is considered to be one of the best tools for testing physics beyond the Standard Model. It seems that existence of processes which violate the $\mathcal{CP}$ symmetry is necessary to answer the mentioned above riddles. Admittedly, the $\mathcal{CP}$ violation has been observed in decays of neutral K and B mesons, but it is insufficient. One has to search for other processes, in other interactions and systems, where this symmetry is violated. In order to disentangle which processes are responsible for $\mathcal{CP}$ violation it is necessary to measure EDMs of various objects. The neutron EDM is particularly interesting because it is expected that it results from the strong interaction and quark EDMs and not from the weak interaction like symmetry violation in decays of neutral mesons. The neutron EDM is measured for 60 years. Up to now, all measured values are consistent with zero. The best limitation of this value, measured by the RAL-Sussex-ILL collaboration in Grenoble, equals to $d_n < 3.0 \cdot 10^{-26}\, e{\cdot}\mathrm{cm}$. Due to these measurements many theoretical models was falsified or had to be modified, e.g. necessary changes of the MSSM models created the so-called “SUSY CP problem”.

Measurement of the neutron Electric Dipole Moment (EDM) with accuracy of below $9{\cdot}10^{-28}\, e{\cdot}\mathrm{cm}$ is a main goal of the presented research efforts. Achieving of such accuracy is eagerly expected, because it will enable verification of most important new theoretical models. The measurement is being performed in collaboration of about 50 physicists from Belgium, France, Germany, Poland, Switzerland, USA and Great Britain at the Paul Scherrer Institute (PSI) in Switzerland. Up to now, we obtained twice better accuracy that the best published result - data analysis is in progress. It is worth noting, that nEDM@PSI measurement is the only neutron EDM measurement which was regularly taking data in the last years and its sensitivity is the best ever obtained in history. However, it is necessary to built the new apparatus to obtain our target accuracy. This project includes its construction, commissioning and testing. The measurement uses ultra-cold neutrons, i.e. neutrons of very small energies, below 250 neV or velocities below 7 m/s. Such neutrons can be closed in special vessels. In order to measure EDM, we use the Ramsey's resonance method of separated oscillatory fields. The ultra-cold neutrons are stored in a vessel, in parallel magnetic and electric fields and frequency of neutron spin precession is measured. The magnetic oscillatory fields, mentioned in the name of the method, are used to rotate neutron spins in order to control the precession time of neutrons. Frequency difference between measurements with both static fields directed either parallel or anti-parallel is a measure of the EDM value. Desired accuracy of the EDM measurement requires knowledge of the magnetic field in a single measurement cycle with accuracy of $3 \cdot 10^{-14}$ T, which can demonstrate the measurement difficulty and quality.

In addition, neutron EDM measurement enable us to estimate or limit mass of axions interacting with matter. The axions are hypothetical particles which are interesting candidates for Dark Matter. Such search for axion effects was performed on the basis of data from the nEDM@PSI experiment[1].

Successful measurement of the neutron EDM, together with measurements of EDM of other objects, measurements of neutron lifetime, searches for unknown particles and forbidden decays of known particles, as well as cosmological and other measurements will contribute to the knowledge of construction of our Universe on the most fundamental level.

[1] Phys. Rev. X 7 (2017) 041034. The publication contains reference to description of nEDM@PSI experiment.