The Nobel Prize in Physiology or Medicine 2009 was awarded jointly to: Elizabeth Blackburn (University of California, San Francisco), Carol W. Greider (Johns Hopkins University School of Medicine, Baltimore) and Jack W. Szostak (Harvard Medical School, Boston) “for the discovery of how chromosomes are protected by telomeres and the enzyme telomerase”. The Nobel Prize in Chemistry 2012 was awarded jointly to: Brian K. Kobilka (Stanford University School of Medicine) and Robert J. Lefkowitz (Duke University Medical Center) “for studies of G-protein-coupled receptors”. The Nobel Prize in Chemistry 2014 was awarded jointly to: Eric Betzig (Howard Hughes Medical Institute), Stefan W. Hell (Max Planck Institute for Biophysical Chemistry, Goettingen) and William E. Moerner (Stanford University) “for the development of super-resolved fluorescence microscopy”.

In the last decades, advances in fluorescence-based techniques such as single-particle tracking (SPT) have allowed to characterize the diffusion of molecules in biological systems with nanometer precision in living cells. Moreover, the new imaging techniques allow acquisition of high-density SPT data in live cells, with up to millions of localization in a
few minutes leading to the Big Data problem. The subject become also a major field in mathematics. In the engineering sciences, in which fractional dynamics has a long-standing history in the description of viscoelastic materials, process control, or the geosciences, it is popular as ever. However, this concept is by now most recognized in applied domains of life sciences such as biological physics, molecular biology or medicine.
The European Molecular Biology Laboratory (EMBL) organized first Conference on “Big Data in Biology & Health“ in Heidelberg, September 25–27, 2016. Moreover, this timely interdisciplinary meeting aimed to enable the European research community to participate in and help drive the future development of big data research, as well as raise further awareness for this new and relevant research direction in the life sciences. Conferences on “Big Data in Biology & Health” will alternate between EMBL Heidelberg and EMBL Hinxton yearly to address the opportunities and challenges of big data.

The above new challenges in the analysis of SPT big data show the necessity of building novel theory and statistical methods to study complex biological systems. These up-to-date issues are the core of our research project. In view of the above challenges and Poland’s expected membership in EMBL from 2017, we propose the following research tasks:

T1. Advancement of mathematical theory of (transient) anomalous diffusion
T2. Development of rigorous statistical inference methods tailored for single particle tracking (SPT) data
T3. Identification, validation and prediction anomalous dynamics in living cells based on big data

We believe that accomplishing these interdisciplinary tasks will result in many interesting discoveries not only in mathematics, but also in physics and biology. It will allow us to find proper models and to understand anomalous processes in living cells in the era of big data.