Recent advances in nanotechnology are paving the way to attain control over individual microscopic objects. The ability to prepare, manipulate, couple and measure single microscopic systems facilitate the study of single quantum systems at the level of individual events. Such experiments address the most fundamental aspects of quantum theory. Indeed, quantum theory gives us only a recipe to compute the frequencies for observing events but it does not describe individual events, such as the arrival of a single electron at a particular position on the detection screen. Reconciling the mathematical formalism (that does not describe single events) with the experimental fact that each observation yields a definite outcome is often referred to as the quantum measurement paradox. It is the most fundamental problem in the foundation of quantum theory.

In this talk, I present an event-based simulation method that rigorously satisfies Einstein's criteria of realism and local causality and builds up the final outcome that agrees with quantum theory event-by-event, just like in real experiments. We show that our event-by-event simulation method reproduces exactly the results of quantum theory for single-photon Mach-Zehnder interferometer, Wheeler's delayed-choice experiments and Einstein-Podolsky-Rosen-Bohm experiments.