The interactions of the fundamental constituents of matter – electrons, photons, and the quarks composing protons and neutrons – are described by the Standard Model of particle physics, which is inarguably one of the most successful theory in the history of science. The particles of the Standard Model have all been experimentally observed: the last to be found was the Higgs boson, discovered at the Large Hadron Collider (LHC) in Geneva in July 2012.

Despite the Standard Model's success, there exist in Nature some phenomena that are not predicted in its framework. The dark matter of the Universe, the mass of neutrinos, the reason for a different number of particles and antiparticles in the Universe, are not explained in the Standard Model. Until recently theorists had grounds to believe that the new theory "beyond" the Standard Model, or BSM, would be connected to the physics of the Higgs boson, and that for this reason many new particles, just a little heavier than the Higgs boson itself, would be observed at the LHC. After nine years and hundreds of measurements, however, none of the predicted BSM theories has found experimental confirmation. At the energy, or *scale*, associated with the Higgs boson the "new world" of BSM physics has not appeared and the particle physics community found itself lost at sea.

Yet, using the experience matured in decades of theoretical investigation as compass, theorists have charted three other "territories" of the particle world, energy scales that can harbor the fundamental theory of Nature. Far far away stretches the Planck scale – the land of quantum gravity, where the strength of gravitational interactions is comparable to the strength of the electromagnetic and weak interactions – which is home to particles a hundred million-billion times heavier than the Higgs boson. The physics of the Planck scale enjoys the best theoretical motivation but is extremely difficult to probe experimentally. Much closer to us we glimpse the presence of a new scale, which could host the particles considered to be the source of the *flavor anomalies*, strong experimental fluctuations emerged in recent years in the data from meson decay at the LHC. These BSM particles may be just a bit too heavy to be tested directly with the beam energy operating at the LHC but are likely within the capability of a more powerful future accelerator. Finally, many theorists believe that just before our eyes may lie the scale of *light mediators*, BSM particles about a hundred times lighter than the Higgs boson. These particles, strongly motivated by the dark matter puzzle, have extremely feeble interactions with the Standard Model that have allowed them to evade detection to these days. However, the astonishingly large datasets and very good background rejection of modern *intensity frontier* experiments give us a very good shot at discovering these elusive objects, just like when watching a football game on HD-TV we are able to make out details of the grass lawn which were completely unresolved in older cathode-ray tube televisions.

The main goal of this project is to establish a long-term research program to draw connections between the different energy scales of BSM physics. This will be achieved through the combination of theoretical assumptions based on first principles and a data-based phenomenological approach.

Theoretical requirements for the physics of the Planck scale and about – based for example on new mathematical symmetries, on the theory of phase transitions, or other – will yield specific boundary conditions for the free parameters of the considered BSM models. Using the techniques of quantum field theory and the renormalization group, I will be able to extract predictions for the mass and interaction strength of the particles sitting possibly at the scale probed by a future proton collider or, more down the energy ladder, at the scale currently tested by the experiments for light mediators.

Viceversa, a bottom-up approach based on the coherent inclusion of all experimental constraints with the appropriate statistical significance will greatly benefit the way we close in on the unknown theory at higher and higher energies. My ultimate goal is to build a bridge between distinct communities in the particle physics world and in the process uncover something fundamentally new. The results of the grant will help to point future financial and intellectual resources in the right direction in the search for the fundamental theory of Nature.