# Particle physics at the precision frontier

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The recent discovery of the Higgs boson candidate, which made international headlines and was named the breakthrough of the year 2012 by the *Science* magazine, is yet another spectacular success of the Standard Model (SM) of particle physics describing sub-atomic constituents of matter and their mutual interactions. Despite being able to describe a vast majority of subatomic processes, the SM has major limitations. In particular, astrophysical data indicate that the Universe is dominated by dark matter of yet unknown nature, while the visible matter known to science constitutes, astonishingly, accounts for as little as 5% of the total mass-energy. The SM cannot explain the observed matter-antimatter asymmetry of the Universe either. This defines the main challenge of particle physics: the search for new types of elementary particles and forces beyond the SM description collectively termed 'new physics'.

**The search for new physics**

Laboratory searches for new physics proceed by two methods. The 'energy frontier' methodology is based on measurements of particle interactions in collisions of highest possible energy, aiming to be above the threshold for production of new heavy elementary particles. This approach is the *raison d'être* for the experiments at the Large Hadron Collider at the European Laboratory for Particle Physics (CERN), and has led to the Higgs candidate discovery mentioned above. A complementary 'precision frontier' approach, which has been tremendously successful historically, is to look carefully at very rare lower-energy subatomic processes that can be accurately predicted by the SM. New physics at high energy scale can manifest itself in dynamical effects at lower energy via quantum loop corrections to the basic processes. Therefore the differences from expectations in such processes would prove the existence, and give information on the form of, new physics.

The NA62 experiment at CERN aiming to collect data in 2014–16 is among the largest modern precision frontier particle physics experiments in the world. It will focus on the studies of the decays of a particular type of unstable particle, the charged kaon. Kaons, one of the lightest quark bound states, have been a copious source of information on fundamental interactions since their discovery in 1947. The Nobel discovery of CP violation, the phenomenon generating the matter-antimatter asymmetry of the Universe, was made in the kaon sector. Owing to a uniquely intense kaon beam provided by the CERN accelerator complex and a range of state-of-the-art detectors, the NA62 experiment will bring kaon physics to a new level of precision. The unprecedented sensitivity opens a range of new opportunities to probe the nature of new physics at the high energy scales.

The primary interest of the Birmingham group within the NA62 experiment lies in testing an accidental symmetry of the SM, the Lepton Flavour (LF) conservation. The recent discovery of neutrino oscillations has led to a conclusion that the LF symmetry is approximate rather than exact. It also implies that the neutrinos have non-zero masses, which (in addition to constituting a non-SM phenomenon by itself) opens the questions about the fundamental properties of the neutrino and the origin of its mass scale.

**Being a Fellow**

I lead a working group of the NA62 experiment dedicated to precision searches for processes violating LF symmetry of the SM and dark matter particle candidates such as the heavy neutrinos. My goal is placing the most stringent constraints on the nature of new physics, or indeed finding an evidence for processes or particles beyond the SM description. Birmingham is an ideal place to undertake this challenge, thanks to the strong position within the NA62 experiment, strong links to the worldwide community and the state-of-the-art laboratory facilities allowing the development of experimental equipment. The award of Birmingham fellowship provided me with independence, enabled me to develop my own research agenda and focus on extending my research group and student supervision.