Statement of Research Interests

My research is focussed on searching for physics beyond the Standard Model (SM) in the flavour sector using model-independent tests of the flavour-changing neutral current $b \to s\ell^+\ell^-$. The $b \to s\ell^+\ell^-$ transition is suppressed in the SM hence is an ideal environment in which to measure the flavour interactions of any new particles. These measurements are an essential part of the search for physics beyond the SM and provide a powerful tool to discover the flavour structure of new interactions. The excellent performance of the LHC, and in particular of the LHCb detector, allows precision measurements $b \to s\ell^+\ell^-$ decays as the data recorded by LHCb is the worlds largest dataset of b-quark decays.

The $B^0 \to K^{*0}\mu^+\mu^-$ decay is a excellent channel to measure the $b \to s\ell^+\ell^-$ transition through measurements of the branching fraction, CP asymmetry and angular observables. We have made the worlds most precise measurement of the angular observables of the $B^0 \to K^{*0}\mu^+\mu^-$ decay. These observables are highly sensitive to new particles and minor discrepancies have been observed in the observable known as $P_5^{`}$. Whilst working on this, I calculated the effects of a $K\pi$ S-wave on the angular observables for the first time. This is caused much theoretical interest, and I followed it up with a theoretical collaboration to calculate the size of the $K\pi$ S-wave.

Related to this, the $B^+ \to K^+\ell^+\ell^-$ decay is a simpler channel which allows for measurements of different leptonic final states. During my post-doctoral position, we tested lepton universality by measuring the ratio of $B^+ \to K^+\ell^+\ell^-$ decays with electron or with muons in the final state. We have measured a deviation from the Standard Model of 2.4 standard deviations and this is the most precise measurement of this ratio in the world.

The Run II dataset from LHCb will allow the determination as to whether these deviations are the sign of something new. To make this possible, and to ensure the continuation of world-beating measurements in other $b \to s\ell^+\ell^-$ decays at LHCb, I will work on the LHCb trigger, of which the CERN group is leading and heavily involved in the development of. I have developed physics triggers for previous physics programmes and will ensure that the physics programme of lepton universality tests will take the highest quality data.

The future of measurements of test lepton universality $b \to s\ell^+\ell^-$ decays requires an understanding of how sensitive observables are to lepton-flavour violating effects, and this is my current project. A detailed measurement of the ratio of $B^0 \to K^{*0}e^+e^-$ to $B^0 \to K^{*0}\mu^+\mu^-$ is next, followed by measurements of decays with ϕ, π and K_1 mesons in the final state along with more precise measurements of the angular distributions. Finally, these measurements can be grouped together into B decays to vector or pseudoscalar meson final states and I plan a combination of measurements with the full LHCb data from Run I and II which will conclusively determine if there are any lepton flavour violating effects in $b \to s\ell^+\ell^-$ decays.

The existence of new particles which violate lepton universality has massive implications for the field of particle physics and these are vital measurements that must be explored in the next few years, using the data from Run I and II of the LHC.