My research interests are primarily in radiation-matter interactions. Below please find a research summary.

When electron or other charged particle beams move through solid matter, a current is necessarily created. This current should create a very strong magnetic field. Based on observed dispersal of electrons in conducting solids such as iron, the fields should be so strong that energy conservation would be violated. This led to the model of the return current of free electrons in the material, which has been reasonably well validated for conductive plasmas, and so is assumed to be the mechanism responsible for current effects in solids. However, solids are very difficult to test directly, as the material itself conceals the phenomenon. Yet, this effect may be of interest in radiation shielding it forms one channel by which charged particle radiation migrates through materials. For exotic materials which are difficult and/or expensive to fabricate and study, simulation may form an avenue of investigation. Little has been done in this area, due to certain difficulties. With this refinement, novel methods of antimatter (positron) generation may be explored on an ultra-fast laser such as that at this university. If a nearly-pure pair plasma can be created, it can be further studied.

Because the phenomenon is an electron-electron interaction, but occurs in solid density matter which has a correspondingly high density of electrons, neither of the two most popular simulation methods, Monte-Carlo and Particle-in-Cell, are suited to study it. However, recent developments in Monte-Carlo-Particle-in-Cell hybrid codes suggest that modelling of this phenomenon should be possible.

Such simulation to calibrate and analyze recent and/or novel detector techniques. My PhD research dabbled in this. Material attentuation, photoactivation, and scattering can all produce statistically predictable results which simulation can analyze. In principle, this can be paired with smart phone app technology to allow quick and relatively inexpensive interrogation of shielded material to search for materials such as illicit uranium.

Either research proposal would involve programming and development which requires some understanding of physics, and the running of the program would require slightly less knowledge of both. This allows roles for both graduate and undergraduate level students to participate. Graduate students, who typically participate in experiments for longer, can learn the basics of physics programing and ultimately develop new programs for use not only by their own research group but also other researchers. Undergraduate students can be taught to run existing or completed simulations, thus learning some of the basics of more general computer programming, and taught what to look for based on knowledge of the underlying physics.

Once a model is functional, testing can be carried out using a combination of commercial radioactive samples, photon or charged particle beamlines such as those used for medical purpose, and high-energy-density systems such as laser-solid systems using a petawatt-class laser. Thanks to use of the simulation, these more expensive tests can be minimized and thus costs reduced for programs that may benefit such as some relating to space travel or fusion.