PhD Internships 2024

Below we describe the four areas candidates can apply for. Within each area, there will be several different projects on which an intern could work. The details of the project will be tailored to the candidate's background.

In each category listed below, we have provided just **one example** of possible projects. Please note there will be **multiple** projects in each category and projects will be allocated according to your background.

Quantum Error Correction Research

Our Quantum Error Correction research team has three themes:

1. Designing and running quantum error correction experiments on quantum processors
2. Inventing new decoding algorithms to catch more errors
3. Speeding up decoders to run faster

We've written papers on hardware decoders, parallelised decoding, twisting schedules approach to logic, and more. As a Riverlane intern, you will work in one of those areas. To give you an idea of a project in this area, we outline below the more specific details for an intern who would like to work on exploratory research into higher-accuracy decoding. Please note that this is an example project. Actual projects will vary depending on the candidate's background and the exciting work we are focusing on at the time of your internship.

Higher-accuracy decoders typically lead to higher error correction noise thresholds, and so, while qubits are still noisy, such decoders are crucial for realising sub-threshold QEC experiments. Longer term, higher-accuracy decoders can reduce the number of qubits needed to reliably execute quantum algorithms. The aim of this project is to develop new decoders with higher accuracy while keeping them efficient to implement in terms of running time and memory resources. You will get to test your decoder on real data from quantum processors provided by our project partners. A higher-accuracy intern would have a background in computer science, physics or mathematics. You would need to be strong in algorithmic and abstract reasoning. Python programming experience is a must and C++ would be an advantage.

Quantum Algorithms and Applications Research

Our algorithms research team works on the quantum algorithms that error corrected quantum computers will run. We've published papers on a variety of exciting applications from quantum chemistry to materials simulations for catalysis, as well as papers on generally applicable algorithmic advances and more. The two main application focus areas right now are in Quantum Chemistry and Materials Science and in Computational Fluid Dynamics. We are seeking candidates with background in **physics, quantum chemistry, mathematical physics or applied analysis**. The candidates do not have to have an explicit background in quantum computing.

As an example, an intern could work on a state-of-the-art algorithm called the Quantum Singular Value Transformation (QSVT). In such a project, you would work on the mathematical foundations of QSVT, the data loading problem, or the optimisation of quantum resources for quantum chemistry and computational fluid dynamics problems.

Building the Quantum Error Correction Stack

At Riverlane, we work on the quantum error correction stack required for quantum computers to scale and unlock a vast range of world-changing applications. The central task of the error correction stack is to implement an error correcting scheme to handle errors that occur on qubits, which enables longer and more complex computations. We are looking for interns who are keen to work on the core challenges in developing the error correction stack. Riverlane's flagship 2023 paper on hardware decoding explains how our DD1 product works, and you could be part of the team building our next big release!

There are several different projects that an intern could work on, including implementing decoders in software or on dedicated hardware, building tools to model noise of different qubit types, or systems integration. Therefore, we are seeking Computer Scientists, Software Engineers, Embedded Engineers, Verification Engineers, Digital Design Engineers, or engineers with expertise in analog/ RF electronics, who have a keen interest in working on challenging problems in quantum error correction. Knowledge of some of the basic concepts in quantum error correction will be an advantage.

Building the Quantum Control System

As a part of the quantum error correction stack, we work on quantum control systems. The example projects include work on experimental control systems, compiler toolchain and runtimes, and fundamental physics simulation of qubits driven by RF sources and sinks under real-world imperfections. Candidates with different backgrounds including in theoretical physics, experimental physics, computer science, electrical and electronic engineering and related disciplines are welcome to apply.

While there will be several projects as described above, we outline the more specific details for the compiler toolchain project.

A compiler is used to translate high-level (circuit, pulse) programs to low-level control system-specific ones. As a compiler intern, you will design and implement compiler passes, working in particular in the middle-end (lowering high-level languages to low-level ones, optimization) and back-end (machine-specific targeting) layers. You will benchmark applications to run optimally on quantum computers. You will have knowledge and experience in compilers, computer architectures, hardware. Maybe you will have built compilers that translate domain specific languages to coprocessors. Even better if you have experience of industrial-strength compiler toolchains like llvm. You will know your C++ (or C, Rust, OCaml) and some Python; you will have some experience of using git, testing frameworks, CI.