Contribution ID: **13** Type: **not specified**

Towards scalability of quantum computation using Ion traps technologies.

One of the major challenges in quantum computation with trapped ions is to scale the system up to large number of ions. In our experiment, we work on the quantum CCD architecture [1], making use of a segmented trap which can load both beryllium and calcium at the same time. The trap has multiple qubit control zones in which we aim to achieve parallel sequences of operations. We have now demonstrated independently many aspects of this architecture, such as quantum logic gates in multiple trap regions, ion shuttling with minimal motional excitation, and sympathetic cooling.

In other to handle the complexity of experimentally demonstrating protocols such as quantum-error-correction, we have developed an FPGA-based controller that can run tens of phase-coherent RF pulses in parallel with fully parameterized pulses and real-time measurements. The experimental sequence is entirely written in C++ allowing for real-time branching and general decision-making to be made conditional on qubit measurements while maintaining phase-synchronous control. With this technology we have demonstrated full control of calcium and beryllium qubits. Using a field-independent qubit in beryllium we have measured coherence times of more than 600 ms.

In order to tackle the problem of fast transport we have developed a 16-channel ar- bitrary wave form generator which calculate the required electro voltages using Tikhonov regularisation and has a cutoff frequency of 50 MHz for each channel. With this approach we are able to perform quit gates by shuttling the ion through a static laser beam. This has advantages for operational latency as well as reducing the requirements on optical control complexity. We have demonstrated these gates for both calcium and beryllium ions. The significant Doppler shifts that we encounter in gates performed on calcium allow us to characterize the velocity profile of our ions during transport.

[1] D. Kielpinski, C. Monroe & D. J. Wineland,Architecture for a large-scale ion-trap quantum computer, Nature 417, 709-711 (13 June 2002)

Primary author: Mr MARINELLI, Matteo (ETH Zurich)

Co-authors: Mr KEITCH, Ben (ETH Zurich); Mrs FLÜHMANN, Christa (ETH Zurich); Mr KIENZLER, Daniel (ETH Zurich); Prof. HOME, Jonathan (ETH Zurich); Mr HSIANG-YU, Lo (ETH Zurich); Mr DE CLERCQ, Ludwig (ETH Zurich); NEGNEVITSKY, Vlad (ETH Zurich)

Presenter: Mr MARINELLI, Matteo (ETH Zurich)