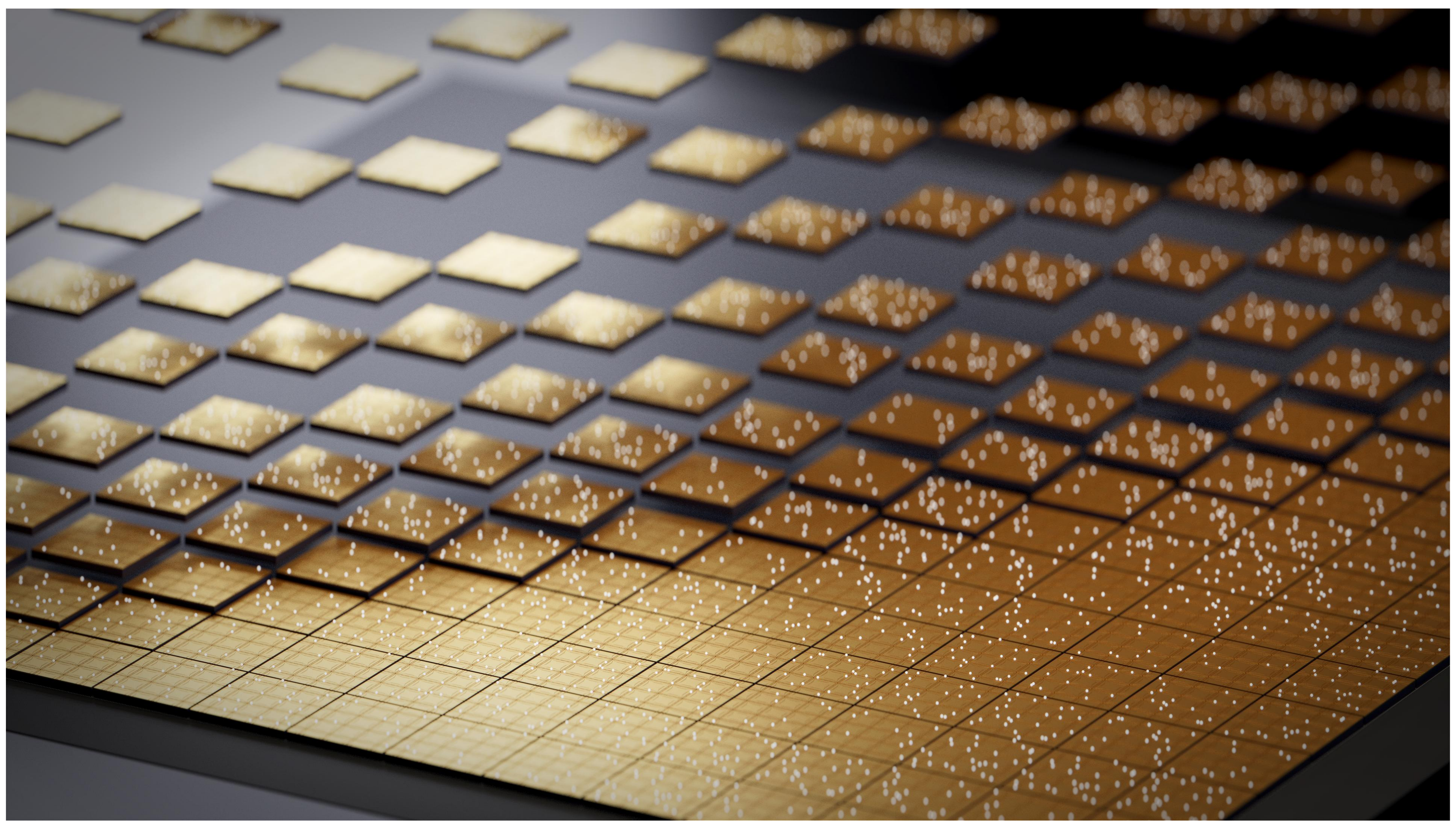
Legato
Universal Quantum‘s Fully Integrated Trapped-Ion Quantum Computer Prototype

- Targeting 20+ qubits running on multiple closely aligned Si technology-based integrated quantum processing units (iQPU). Our key technology UQConnect allows the modules to be directly interconnected, which means qubits can be rearranged across neighbouring iQPUs as if they are held on a single continuous surface.

- Full stack quantum computer
- End-user accessible cloud infrastructure
- High-speed real-time electronics
- Scalable control facilitated by an ASIC
- Global lasers addressing multiple qubits
- Ultra-high vacuum chamber
- Mild cryogenics by operating at 70 K



Approach

Modularity is crucial for realizing trapped-ion quantum computers with millions of qubits. The interconnection of individual quantum computer modules is often described as one of the biggest problems in this regard.

To enable scalability we aim to coherently connect several independently operating trapped ion modules together. These modules are based on the QCI “Toccata” quantum computer prototype and are based on Si chip technology.

For the QCI Legato project, two standalone modules hosting at least 10 qubits each will be interconnected. Qubit numbers and the number of modules can be further scaled up.

UQConnect

The coherent connection between the modules is implemented using *UQConnect.* This mechanism is implemented by aligning the edges of neighboring modules with sufficient precision such that the confining fields of each module extend over to the neighboring modules, thereby realizing an electric field link.

UQConnect enables connection speeds that are orders of magnitude faster than other existing methods to scale beyond individual trapped ion modules while utilizing a much simpler mechanism, where the control signals are comparable to those required for ion transport within a single module. In an experimental demonstration of *UQConnect* we were able to realize coherent transport of a qubit between two neighboring modules with a connection rate of 2424 connections per second and a lower bound interconnection fidelity of 99.999993 %.

Just like in the *Toccata* QCI project we use our global RF-field technology for the execution of quantum gates across the modules. The advantage is that the number of microwave fields required remains the same, even if the number of qubits is increased. In addition, while in many other quantum computing approaches the chip must be cooled almost to absolute zero, our technique works with mild cooling to approximately 70 K (ca. -200 °C), which significantly simplifies the design and reliability of the system.

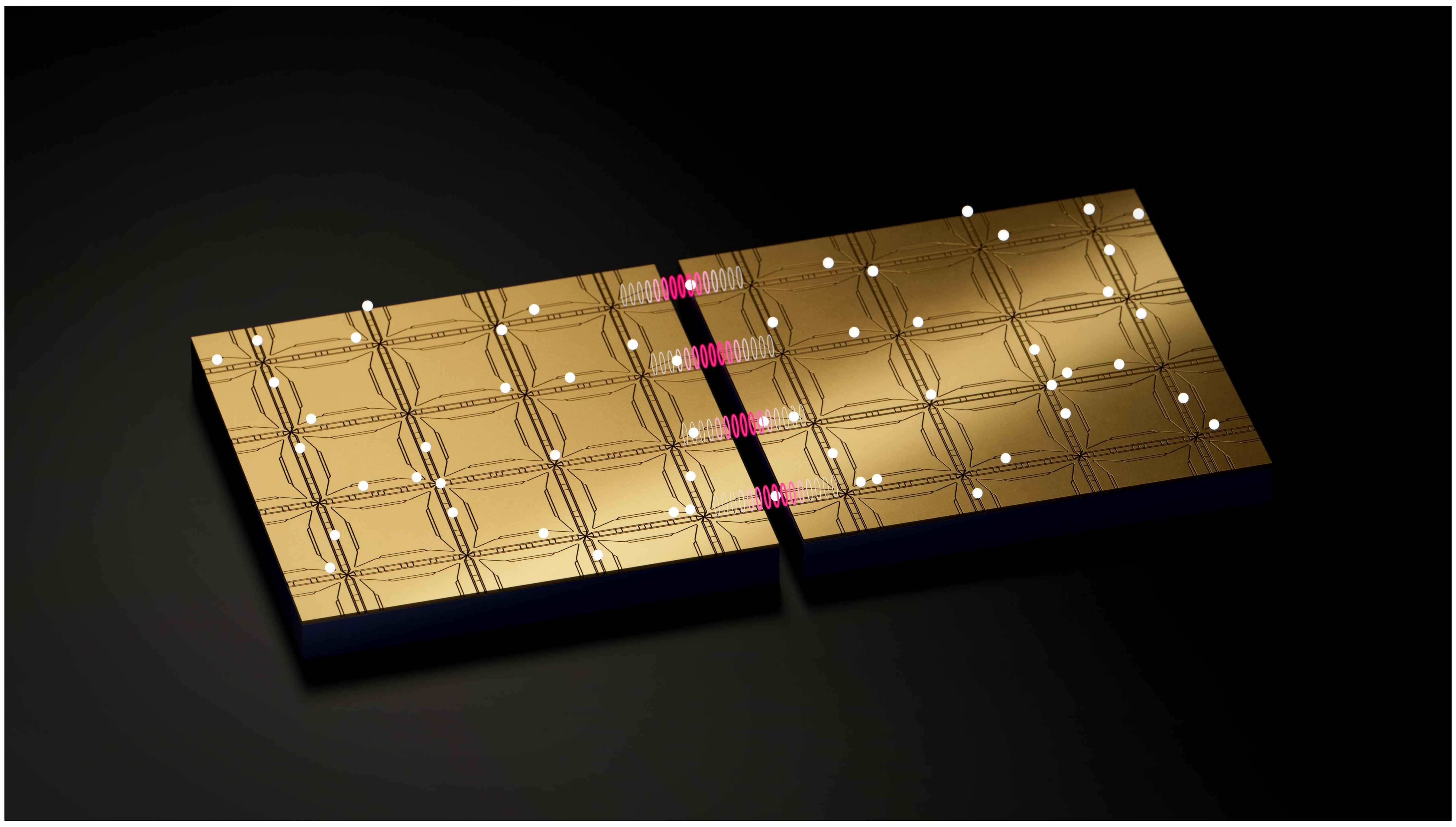


Fig. 1: Representative figure of the *UQConnect* scaling mechanism implemented in the Legato Quantum computer prototype

Multi Module operation

Our approach to scalability relies on spatial translation of the physical qubits. This approach is highly compatible with our choice of qubit platform: Trapped ions. To confine (trap) these particles requires the use of RF and DC electric fields. These generate a time-averaged confining potential for the ions, leading to static confinement. By simply translating the confinement potential, the trapped ions, and therefore also the quantum information encoded in these ions is also translated. Translation of ions within single module has been well established over the last decades. At UQ we extend this approach to span multiple modules. This can be achieved using careful design of the ion trap geometry as well as the ion transport waveforms.

This approach to scaling ion trap systems then makes it possible to connect individual modules (unit cells) that can operate stand-alone, and thereby can function as part of a larger system. Furthermore, despite the increasing size of the system, the total number of control signals that are used to manipulate the spin qubit remain constant.

Find Out More

A growing Team in Germany

Trapped ions

Developing, designing and building a quantum computer requires an interdisciplinary team of highly specialised personnel. At UQ we have teams of physicists, microfabrication, packaging and electronics engineers, software developers along with operations and business departments. This talent is required to achieve our goals!

Fig. 2: Part of the team in Germany

A project of:

Deutsches Zentrum für Luft- und Raumfahrt
German Aerospace Center

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Gefördert durch:

Bundesministerium für Wirtschaft und Klimaschutz

aufgrund eines Beschlusses des Deutschen Bundestages