

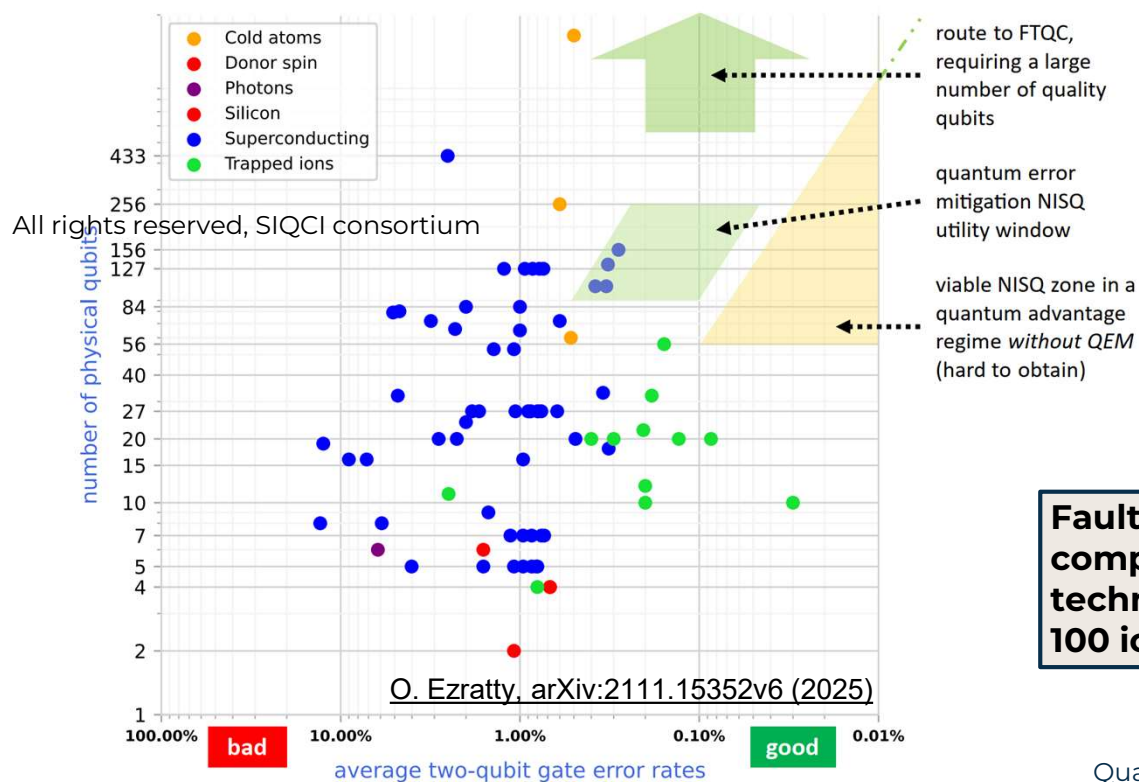
Call 2021
Final Evaluation



SIQCI

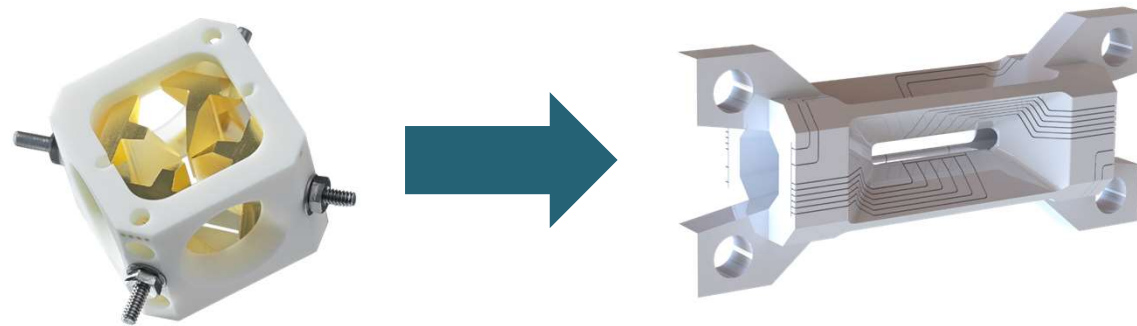
Scalable Architecture for Ion-Trap Quantum Computing
Integration
Juris Ulmanis

CHALLENGE: SCALING UP QUANTUM COMPUTING HARDWARE



Fault tolerant quantum computing requires technologies to operate with 100 ions and beyond.

SOLUTION: TARGETED BUILDING BLOCKS



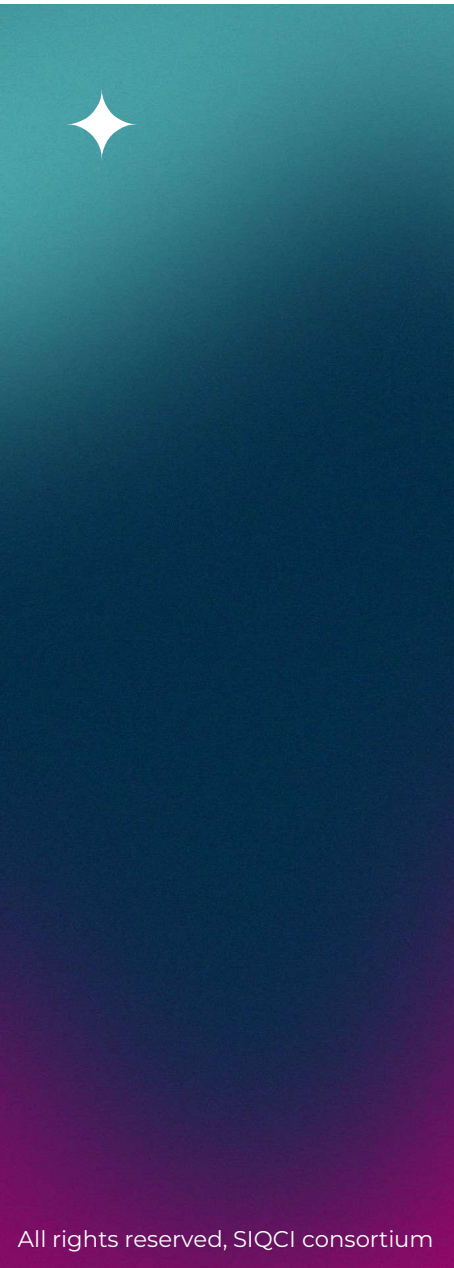
Qubit chip: development of low-noise three-dimensional ion traps with segmented electrode structure

Real-time control: scalable, low noise electronic circuits for segment control at room temperature and cryogenic conditions.

Scalable compilation: efficient compilation of quantum algorithms into low-level instruction circuits for zoned processor architectures.

See also work from Zurich, Mainz, Cambridge, Sussex, Villach, Seoul, Tel Aviv, ...

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COLLABORATION (overview)



GEOGRAPHICAL BREADTH

- Alpine Quantum Technologies (Austria)
- Warsaw University of Technology (Poland, widening)
- Cambridge Quantum Computing -> Quantinuum Germany (Germany)



VARIETY OF SECTORS, DISCIPLINES

- Ion-trap chips, quantum information processing, quantum optics, systems integration
- Cryo-electronics, real-time signal processing, ASIC and FPGA design
- Compilation and transpilation methods heuristic application benchmarking
- 1 academic + 2 commercial partners



QUALITY OF COOPERATION

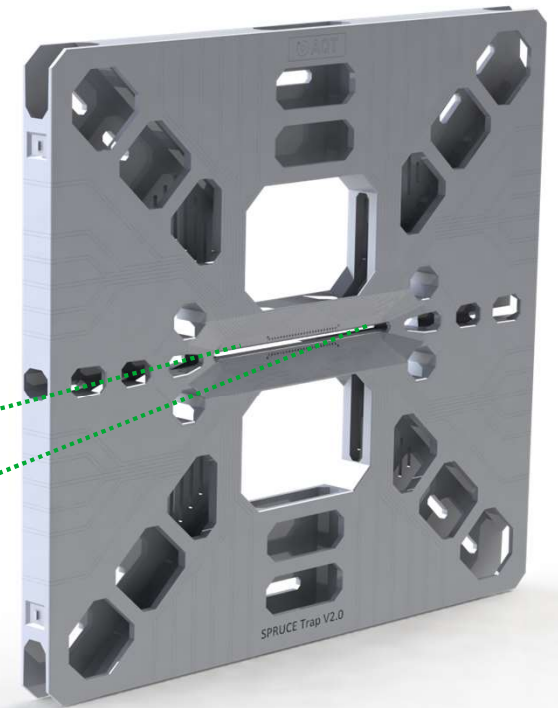
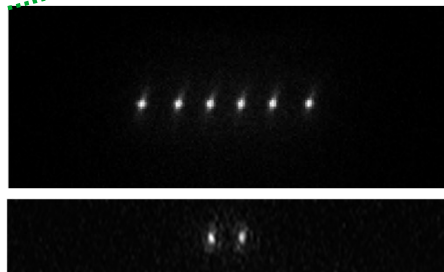
- All milestones achieved
- Regular project meetings – bilateral & all-consortium
- Plans for exploitation and valorisation



OUTCOMES (highlights)

Micro-manufactured segmented ion trap (AQT)

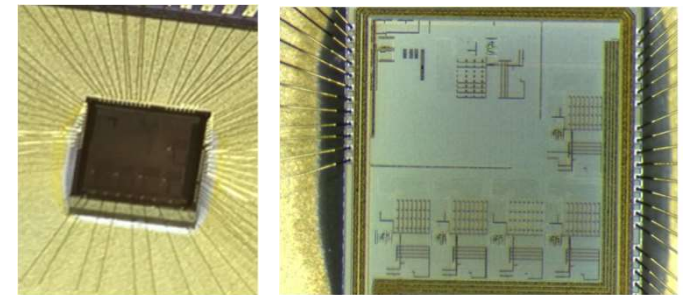
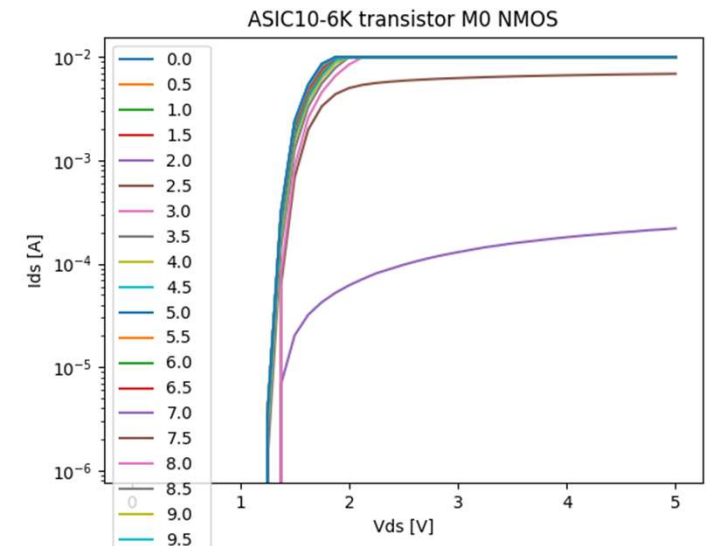
- Monolithic, alignment-free design
- High-NA optical access
- Several re-configurable trapping wells
- Individual electrical control and compensation of each well
- Metallization and manufacturing



OUTCOMES (highlights)

Modelling and characterization of electronic material systems at cryogenic temperatures (WUT)

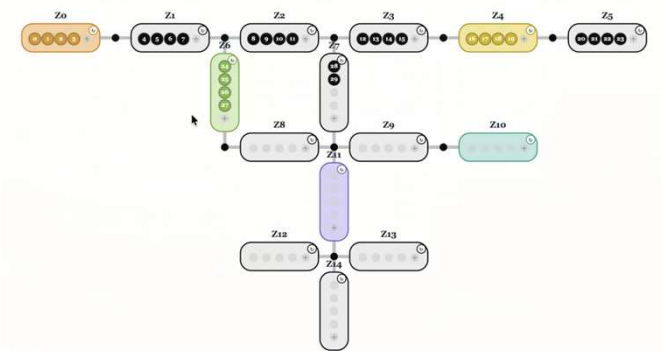
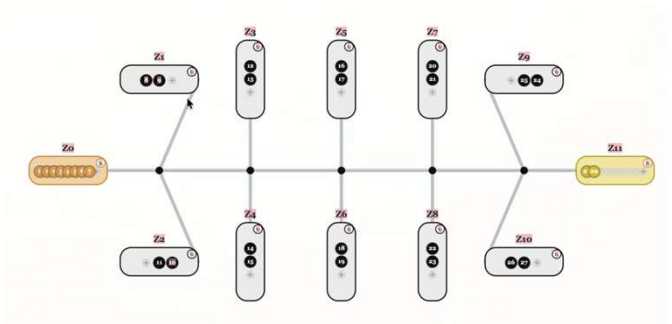
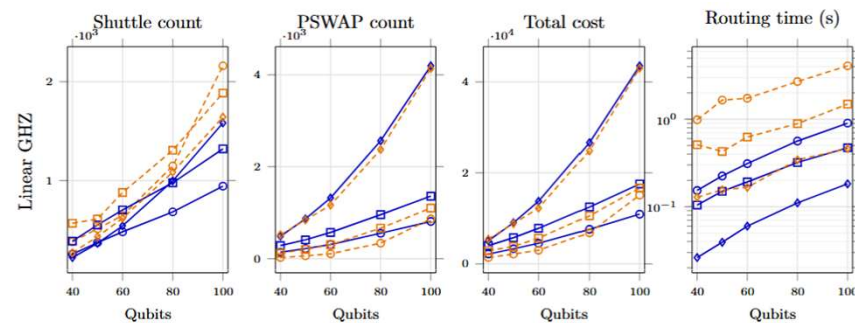
- Precise 12 and 14 bit DACs (180 nm, XFAB) with advanced calibration to tackle 4K environment
- Various test points and diagnostic features to acquire several hundred parameters
- Automated test bench
- Diagnostic toolbox for in-line characterization of the signal chain



OUTCOMES (highlights)

Routing compiler framework for quantum charge-coupled device ion-trap processors (Quantinuum)

- Separation between architecture description, gate and ion selection and placement, and qubit routing
- Flexible interface
- Benchmarking of trap architecture
- Open source

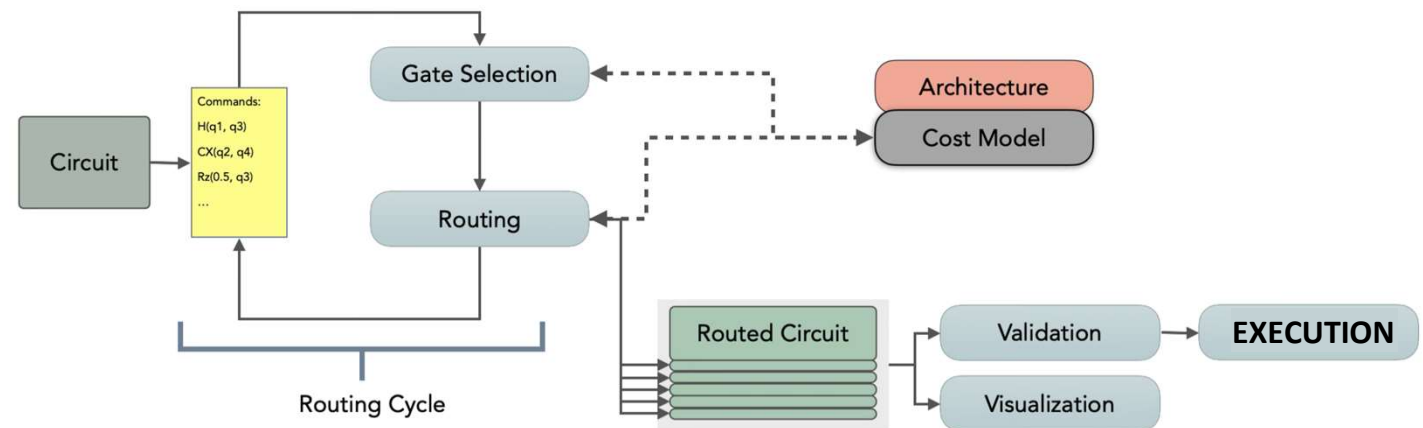


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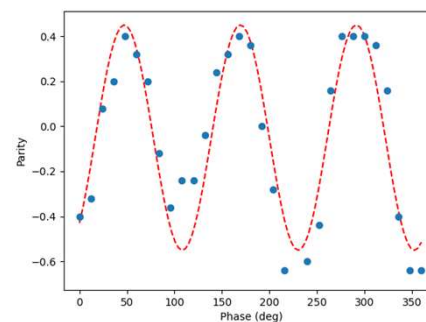
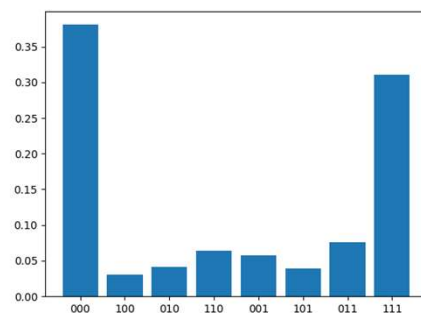
OUTCOMES (highlights)

Software and hardware validation
through integration and system
characterization

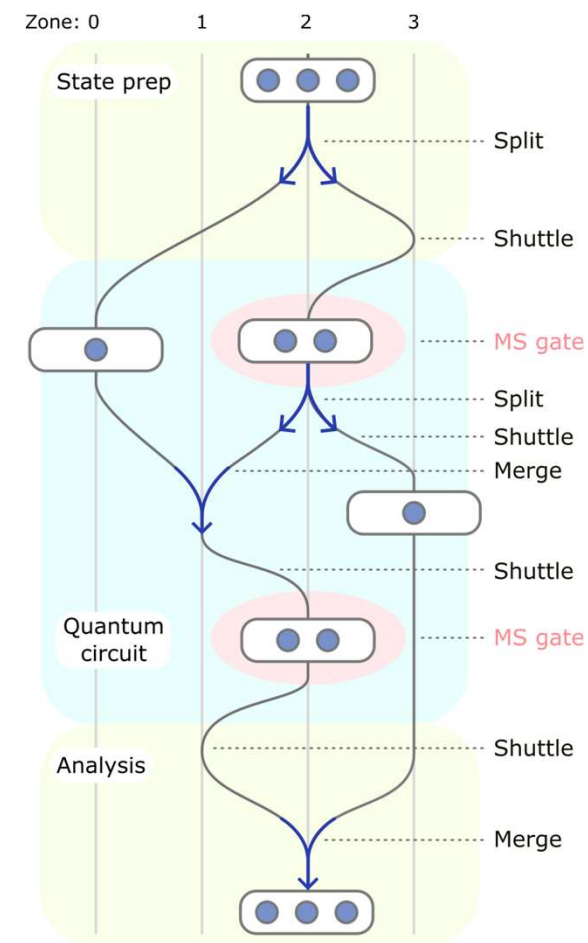


OUTCOMES (highlights)

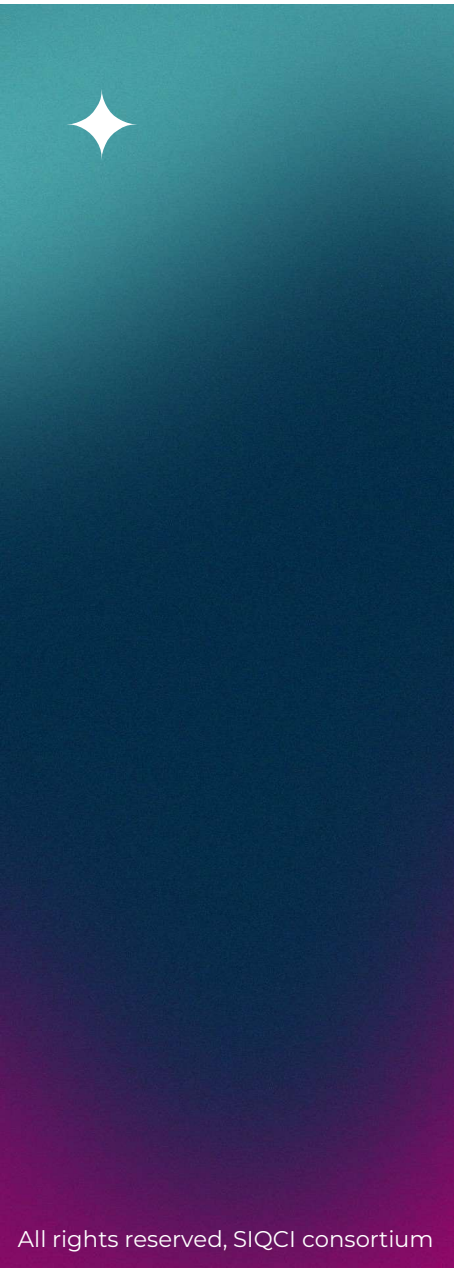
Software and hardware validation
through integration and system
characterization



GHZ state fidelity: 60%



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SCIENTIFIC OUTPUTS



PUBLICATIONS AND PRESENTATIONS (highlights)

- 7 publications and posters
- 14 presentations (e.g. World of Photonics, European Quantum Technologies Conference, Laser Congress)



PATENTS (obtained and pending)

- 1 patent obtained (WUT)



NUMBER OF BACHELOR, MASTER AND PhD THESES

prepared under the QuantERA Project

- 2 PhD theses (Adam Borkowski, Andrej Wojciechowski)



IMPACT (potential users)



KEY COMMERCIALY RELEVANT **APPLICATIONS**

- Quantum computing
- Quantum networking
- Quantum sensing and metrology (clocks)



EXISTING/POTENTIAL **END USERS**

- Quantum excellence and competence centres
- HPC and data centres
- Academic and industrial R&D labs
- Quantum technologies software and hardware vendors



COOPERATION WITH THE **QUANTUM FLAGSHIP** OR OTHER QUANTUM INITIATIVES

- MILLENION, QIA and PASQUANS Quantum Flagship projects, European Quantum Chips Act, Eureka Association



sinara-hw.github.io



<https://github.com/Quantinuum/tket>

TKET



www.aqt.eu/qc-modules/



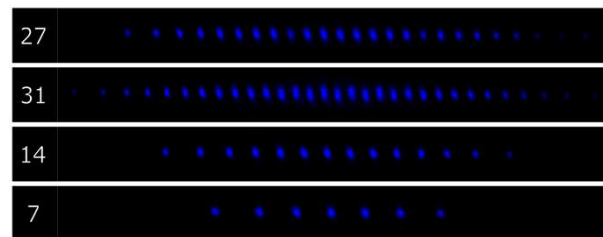
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WHAT'S NEXT

MORE IONS

AQT demonstrates 79 ions
Manufacturability, process
reliability, yield and improved
packaging

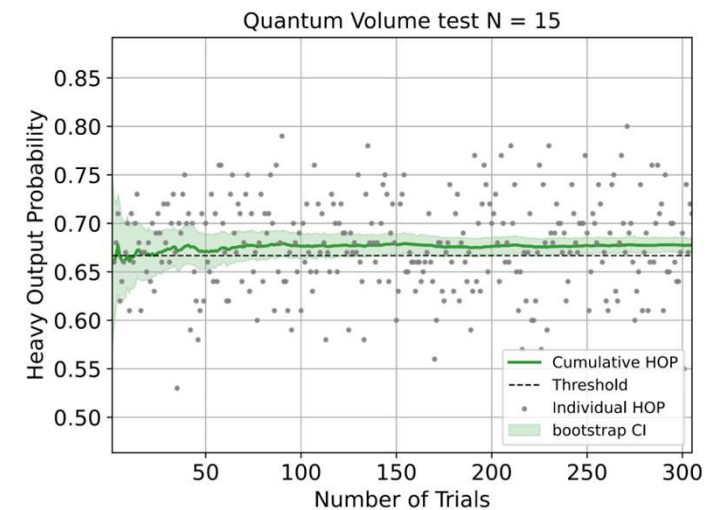


Continuation of (some) activities
within the **project FALCON** from
the **QuantERA Call 2025!**

Check out the poster from
Dr. Thomas Monz!

BETTER GATES

System LYNX achieves European
record and 2nd world-wide in holistic
system performance (Quantum
Volume of $2^{15} = 32768$)



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**Warsaw University
of Technology**

