

6

Partner institutions

4

European countries

4

Scientific disciplines

1

Shared language: control theory

The challenge

Quantum computing is on track to change how we design and run numerical algorithms for a wide range of impactful applications. Two main barriers:

Fragile hardware

Today's devices suffer from a number of error sources that hinder scalability beyond classical limits.

Narrow algorithms

Even with ideal hardware, use-cases are limited to a selected set of algorithms with proven or expected speedups.

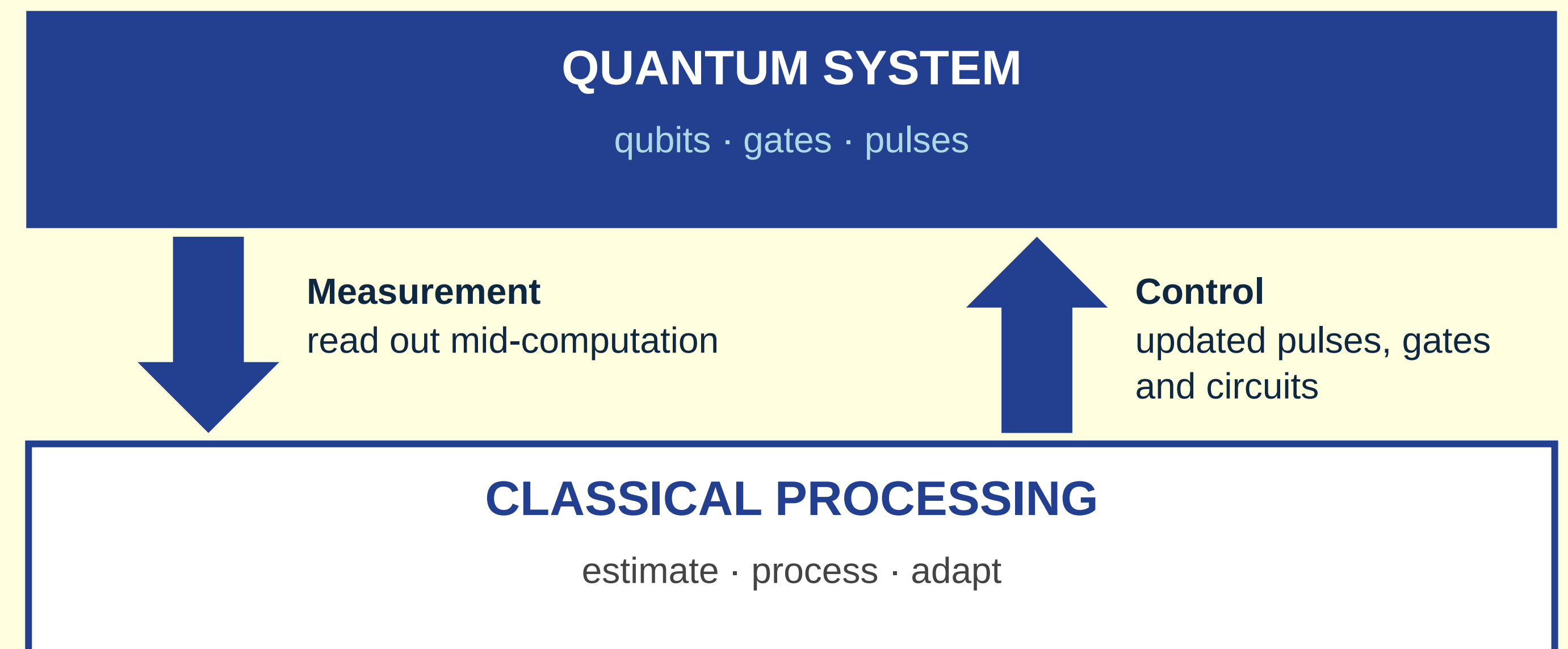
Our target: optimization

Solve broad classes of optimization problems on quantum computers.

Limitations of existing methods: Specific optimization problems, unclear computational advantage, gap to application relevance.

The key idea: Feedback

FeedbacQ monitors a quantum system while it computes and uses the information obtained to guide its behaviour in real time. Feedback is a standard tool in control engineering, but it is not yet fully exploited in quantum computing.

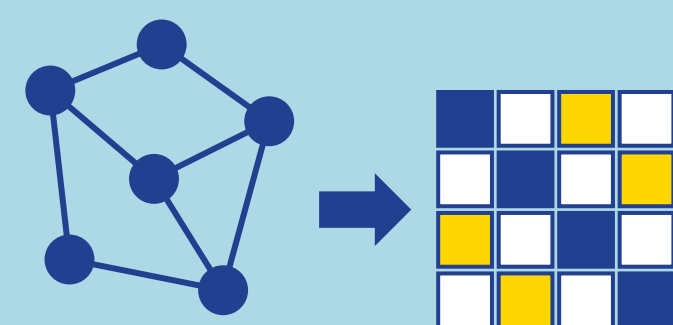


Research programme: feedback at every level

1 Problem mapping

Translating real-world optimization problems into forms a quantum computer can handle.

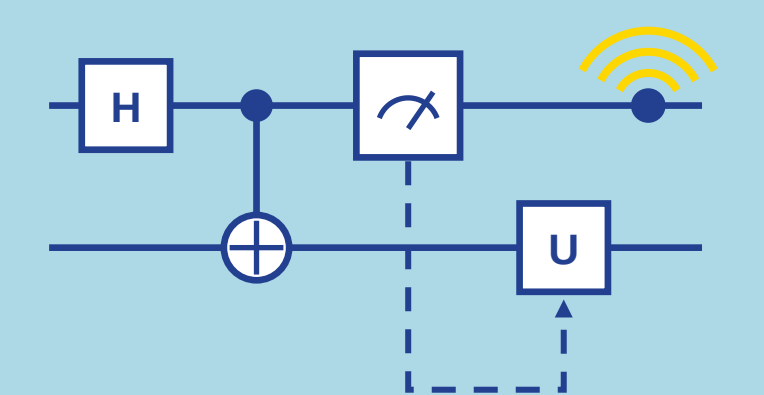
- Nonlinear, combinatorial, and time-dependent problems
- Case studies: Power grids, space missions, learning
- Open-source software toolbox



2 Algorithms

Novel algorithms that exploit measurement and interaction with the environment.

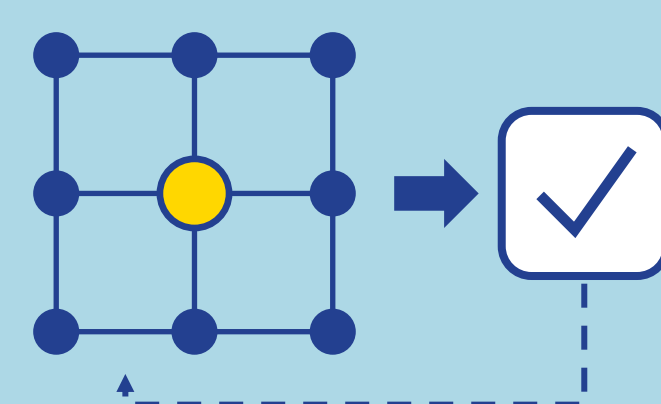
- Dynamic algorithms based on quantum feedback control
- Digital quantum walks
- Dissipative state preparation



3 Error correction

Protecting computations by continuously monitoring and correcting.

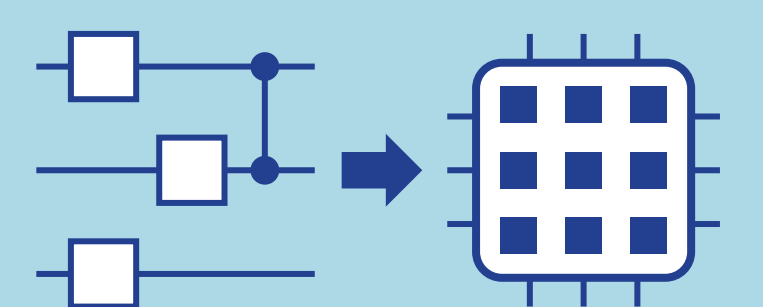
- Continuous-time quantum error correction
- Coherent feedback strategies
- Optimization-based code design



4 Compilation

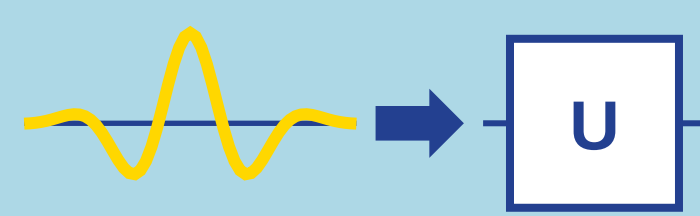
Implementing these methods efficiently on real quantum devices.

- Dynamic circuits
- Discretizing error correction
- Device-level application



5 Gate synthesis

Robust and learning-based design of the control pulses that realize quantum gates.



6 Coordination and outreach

Management, dissemination, training, public engagement, Workshop on feedback in quantum computing.



Expected outcomes and impact

A feedback-based framework

Methods for mapping optimization problems, solving them, reducing errors and synthesizing gates.

Results on real problems

Complex nonlinear and combinatorial optimization problems from a range of application domains solved on quantum computers.

Validation on hardware

Experiments at gate and circuit level, in simulation and on real devices, including a gate-based machine at a partner institution.

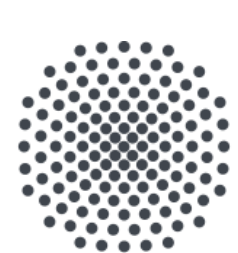
Tools and people

Open-source software for translating optimization problems and researchers trained across four scientific disciplines.

The consortium

physics · mathematics · engineering · computer science

Coordinator



University of
Stuttgart

Julian Berberich
University of Stuttgart
Germany

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Partner 2



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