Chair of Computer Architecture and Parallel Systems
Department of Informatics
Technical University of Munich

Q-BEAST Preliminary Meeting

LRZ

Dr. Minh Chung, minh.chung@lrz.de

Dr. Amir Raoofy, amir.raoofy@lrz.de

Dr. Xiaolong Deng, xiaolong.deng@lrz.de

TUM

Yaknan Gambo, yaknan.gambo@tum.de (Chair Prof. Schulz)

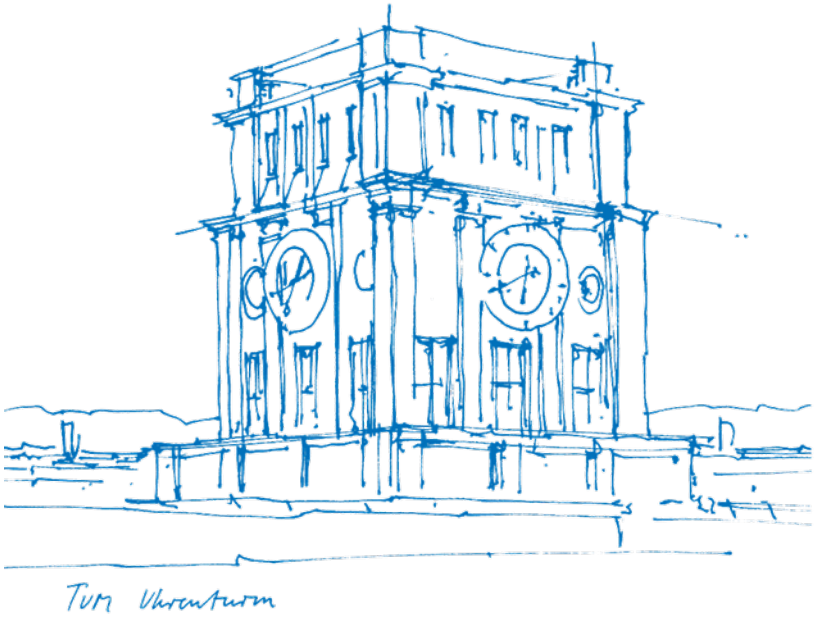
Burak Mete, burak.mete@tum.de (Chair Prof. Mendl)

LMU (Chair Prof. Kranzlmüller)

Korbinian Staudacher, korbinian.staudacher@nm.ifi.lmu.de

Michelle To, michelle.to@nm.ifi.lmu.de

Florian Krötz, florian.kroetz@nm.ifi.lmu.de



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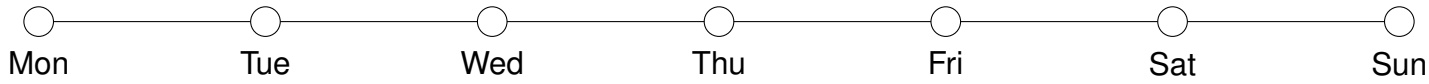
Weekly Schedule

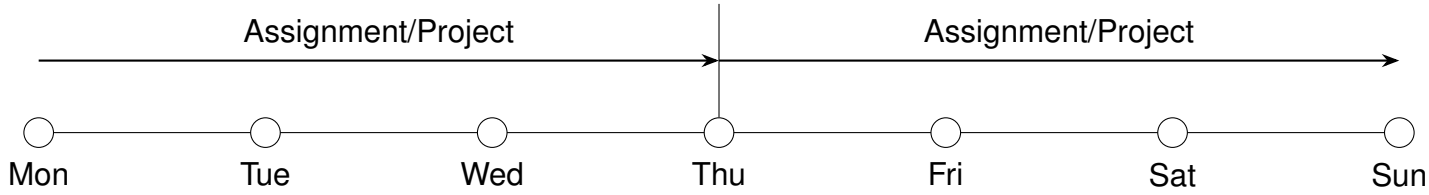


Lab Meetup

16:00-18:00

+ Theory/Vendor Presentation
+ Previous Assignment Presention || Tutorial/Exercise Discussion
+ Next Assignment Introduction

Weekly Schedule



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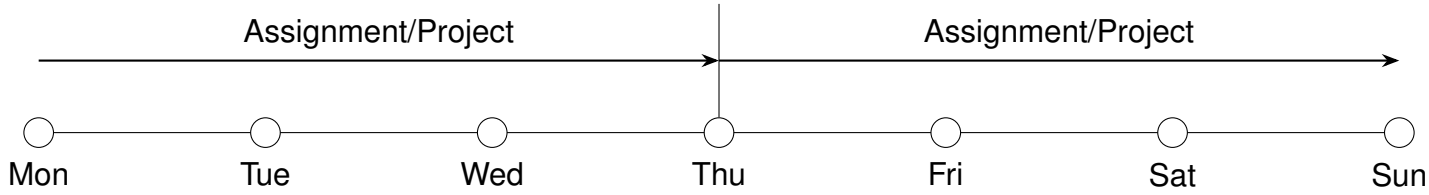

Announcement (E-Mail)
2-3 groups chosen to present

Lab Meetup
16:00-18:00
+ Theory/Vendor Presentation
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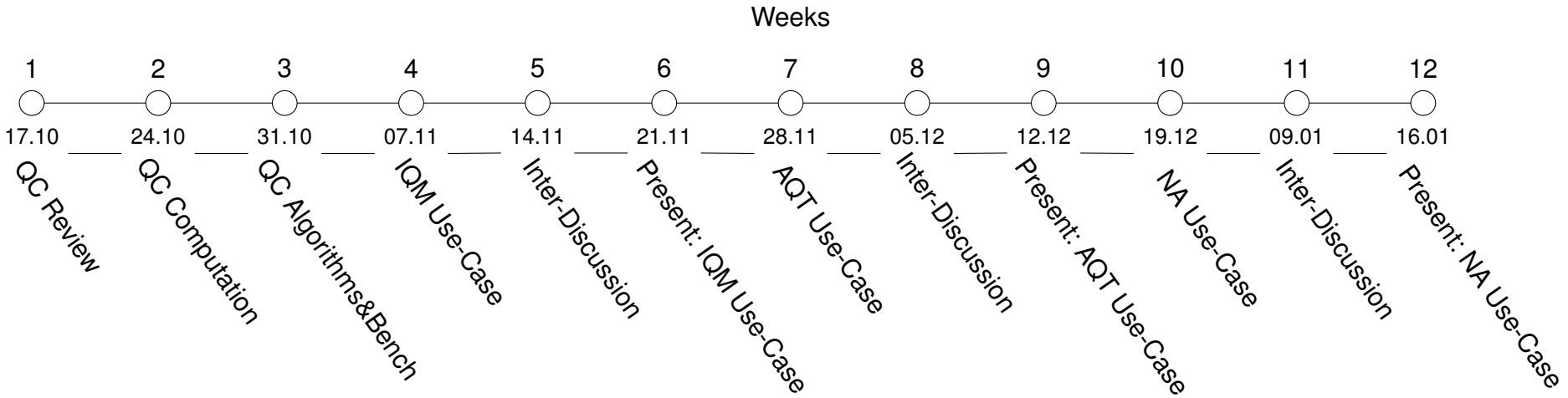
+ Next Assignment Introduction

Tentative Semester Overview



Organization

- Note: This is preliminary plan and is subject to improvements
- 6 Assignments (1-2 weeks/each)
- 1-2 Projects (2-3 weeks/each)
- Student groups of 3 (Bachelor) or 2 (Master)

Vendor Talks

IQM

AQT

Neutral atoms

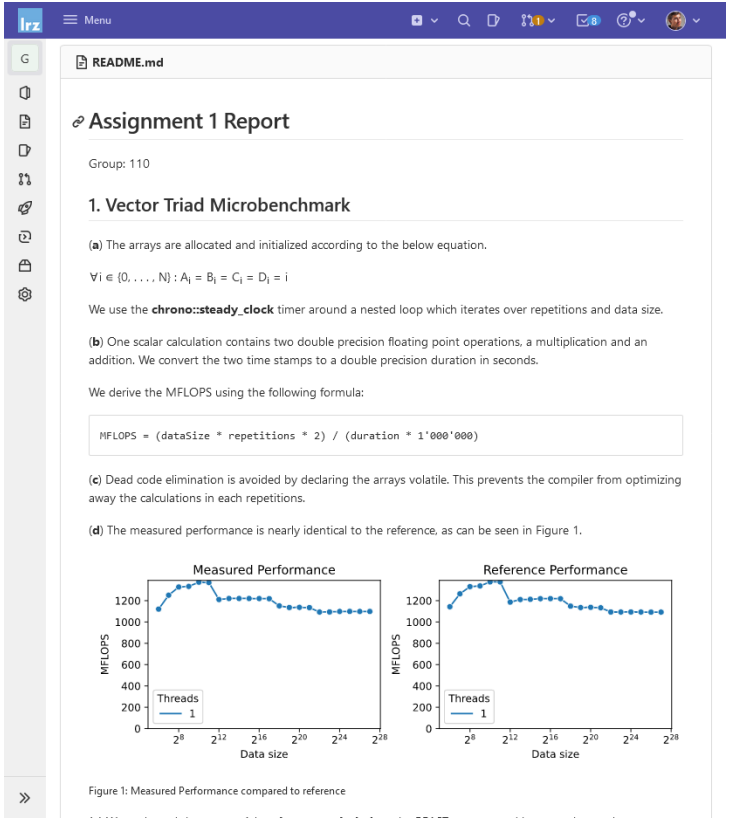
Deliverables/Grading

Git Repository

- **Assignment/Project Report** in Markdown
- Your Code

Presentation

- No slides. Go through the report
- Talk about what you learned from the assignment & experimental results
- Q&A



Next Steps

Register on Matching System

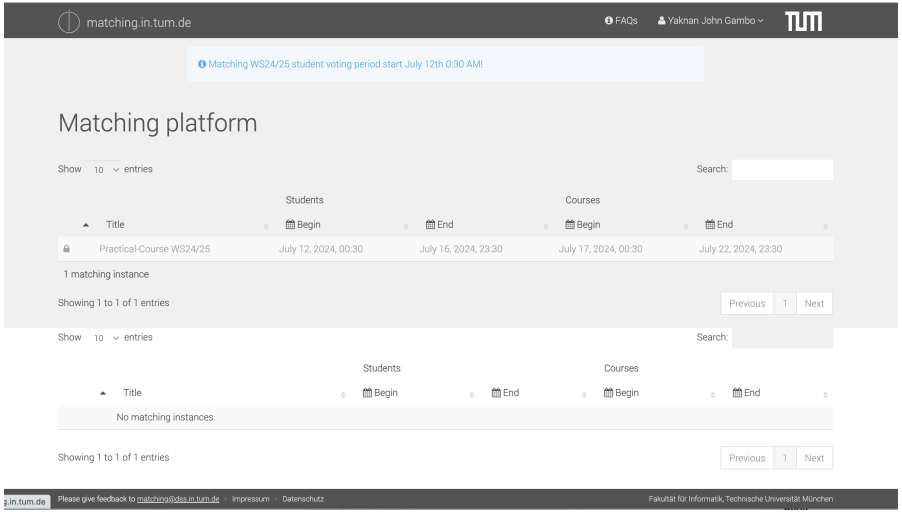
- We will prioritize you if you attended today
- Open until 12.07.2024
- Wait for announcement of matching results (25.07.2024)

Group Preferences

- Only after matching has ended
- Send us by e-mail (yaknan.gambo@tum.de)
- No preferences submitted → we will match you

Attend Course Kickoff

- At university if everything goes according to plan
- We hope to see you there :)



Up Next: Introduction to Q-BEAST

Q-BEAST: Experimental Evaluation and Characterization of Quantum Computing Systems

Collaboration Among 3 Institutions

LMU (Chair Prof. Kranzlmüller)

- Korbinian Staudacher
- Michelle To
- Florian Krötz

TUM (Chair Prof. Schulz & Chair Prof. Mendl)

- Yaknan Gambo
- Burak Mete

LRZ

- Minh Chung
- Amir Raoofy
- Xialong Deng

Quantum Systems at LRZ

Superconducting Technology

System 1: 5 qubits (R&D system)
+ Vendor: IQM
+ Accessible: 2023

System 2: 20 qubits (R&D system)
+ Vendor: IQM
+ Accessible: H1-2024 to select research partners

System 3: 20 qubits
+ Vendor: IQM
+ Accessible: Late H1-2024 to Bavarian, German, and European users in the pilot phase initially, with wider access in 2024

More info at https://www.quantum.lrz.de/

src: https://www.quantum.lrz.de/bits-of-qubits/detail/in-the-future-we-will-use-different-computing-methods-side-by-side

src: https://www.quantum.lrz.de/bits-of-qubits/detail/germany-launches-its-first-hybrid-quantum-computer-at-leibniz-supercomputing-centre

Quantum Systems at LRZ

Ion-trapped Technology

System 1: 20 qubits
+ Target system for software development initially with Munich Quantum Valley
+ Accessible: TBA

AQT

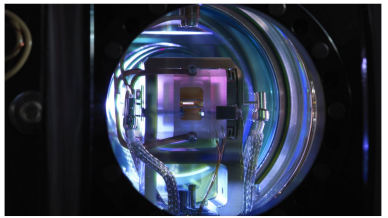
Munich Quantum Valley DE

A trapped-ion quantum computer for Munich Quantum Valley

05 December 2023

News | Press release | High Performance Computing | Quantum Computing | Quantum Hardware | Science | Industry | Public | Q-DESSI

In cooperation with Munich Quantum Valley, the Leibniz Supercomputing Centre is procuring a quantum computer based on trapped-ion technology.



More info at https://www.quantum.lrz.de/

Quantum Systems at LRZ

Neutral Atom Technology

Focus: Experimental Evaluation

We want you to learn and get experience in performance evaluation

- Between quantum simulators and realistic quantum machines
- On different quantum technologies

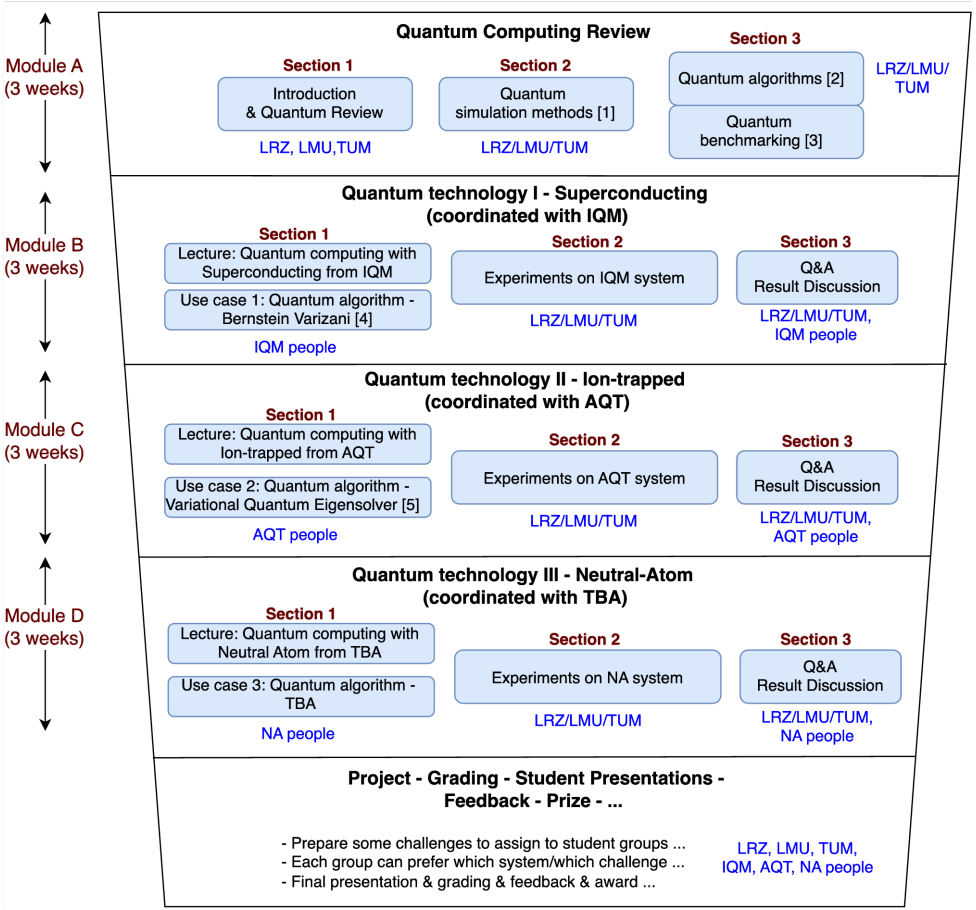
Part 1: get started with small given codes with

- Quizzes/tutorials during weekly meetings
- Assignment with experiments across systems
- Q&A → Discussion → QC experiments in practice

Part 2: working with the use cases from the vendors

Part 3: working with a realistic use-case or application

Focus: Experimental Evaluation



[1] Kieran Young, Marcus Scese, Ali Ebnenasir. Simulating Quantum Computations on Classical Machines: A Survey, 2023, https://arxiv.org/abs/2311.16505.
[2] Montanaro, A. Quantum algorithms: an overview. npj Quantum Inf 2, 15023 (2016), https://doi.org/10.1038/npjqi.2015.23.
[3] Thomas Lubinski, Joshua J. Goings, Karl Mayer, others. Quantum Algorithm Exploration using Application-Oriented Performance Benchmarks, 2024, https://arxiv.org/abs/2402.08985.
[4] https://www.iqmacademy.com/curriculum/algorithms04.html
[5] https://www.aqt.eu/molecule-simulation-on-a-quantum-computer/

Target Architectures for the Lab

- Classical computing nodes (BEAST system)
  - For running quantum simulators
  - For performance characterization

- Quantum computing systems
  - Superconducting (from IQM)
  - Ion-trapped (from AQT)
  - Neutral atom (from …)

Organization

- Work in student groups (expected to split up the work equally)
- Weekly meeting (Thursday, 16:00 – 18:00)
- Assignments
- Final project

Prerequisites

- Basic knowledge of Quantum Computing
- Familiar with computer architecture & HPC
- Interested in QC & HPC
- Knowledge of Python, C++, Linux

Leibniz-Rechenzentrum der Bayerischen Akademie der Wissenschaften

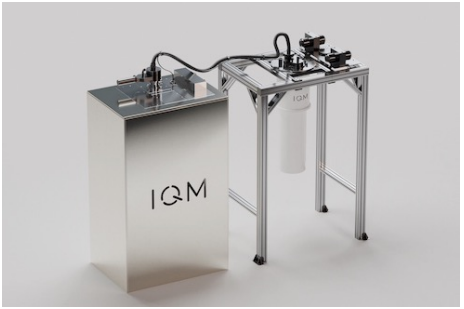
IQM 5-Qubits Machine

Technical specification

PROCESSOR: 5 qubits	GUARANTEED	TYPICAL
Single-qubit gate fidelity	≥ 99.7%	≥ 99.9%
Two-qubit gate (CZ) fidelity	≥ 96%	≥ 98%
Single-qubit gate duration	≤ 60ns	≤ 40 ns
Two-qubit gate (CZ) duration	≤ 100 ns	≤ 60 ns
Readout fidelity *	≥ 92%	≥ 95%
Quantum volume*	≥ 8	≥ 8
Q-score*	≥ 4	≥ 5

*with TWPA option ordered

https://www.meetiqm.com/products/iqm-spark



src: https://www.quantum.lrz.de/bits-of-qubits/detail/in-the-future-we-will-use-different-computing-methods-side-by-side

IQM 20-Qubits Machine

What are the latest performance benchmarks of IQM hardware?

With our latest benchmarks measured on the 20-qubit quantum computer, we have demonstrated a median two-qubit (CZ) gate fidelity of 99.51% across 30 qubit pairs, with maximum fidelity over a single pair reaching as high as 99.8%.
Among the system-level benchmarks IQM obtained:

- Quantum Volume (QV) of 2^5=32
- Circuit Layer Operations Per Second (CLOPS) of 2600.
- 20-qubit GHZ state with fidelity greater than 0.5.
- Q-score of 11

https://www.meetiqm.com/products/iqm-radiance

src: https://www.quantum.lrz.de/bits-of-qubits/detail/germany-launches-its-first-hybrid-quantum-computer-at-leibniz-supercomputing-centre