

Call 2021
Final Evaluation



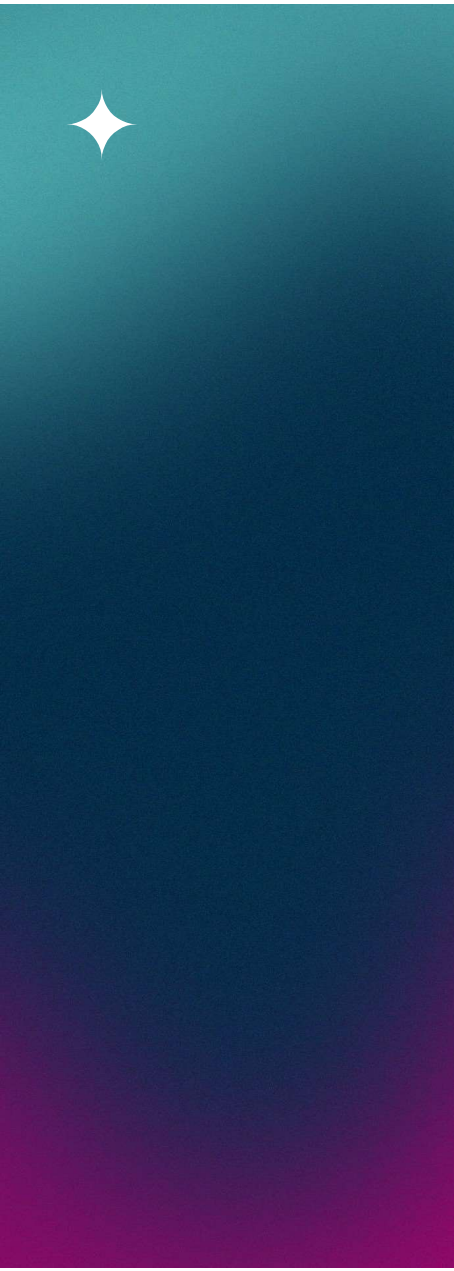
QuantumGuide

Hollow-core fiber atom guide for quantum devices
Juris Ulmanis



Our vision: delivery of atoms on demand

- Many quantum devices (computation, sensing, optical clocks, ...) require laser-cooled atoms.
- Ovens or ablation targets traditionally used as sources degrade the vacuum quality, emit black-body radiation, and take up a substantial volume of the device.
- In QuantumGuide, we develop sources of laser-cooled atoms, as well as delivery through hollow-core fibers, to feed pre-cooled atoms right into the device, on-demand.



COLLABORATION (overview)



GEOGRAPHICAL BREADTH

- University of Bonn (Germany)
- Paul Scherrer Institut (PSI, Switzerland)
- Nicolaus Copernicus University in Torun (Poland)
- Technical University Darmstadt (Germany)
- Alpine Quantum Technologies (AQT, Austria)



VARIETY OF SECTORS, DISCIPLINES

- Quantum computing (PSI)
- Optical clocks (Torun)
- Quantum optics (Darmstadt)
- Quantum gases (Bonn)
- Industry partner (AQT)



COLLABORATION (overview)



QUALITY OF COOPERATION

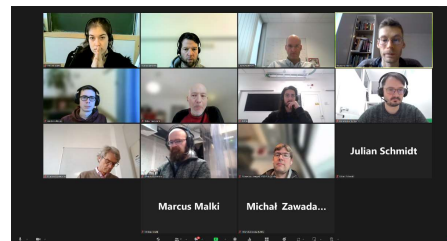
- Yearly conferences
 - 2022: Kick-off meeting
 - 2023: Darmstadt
 - 2024: PSI/ETH Zurich
 - 2025: Innsbruck
- Online Quarterly Meetings + status reports
- Countless bilateral visits, student exchange, joint publications

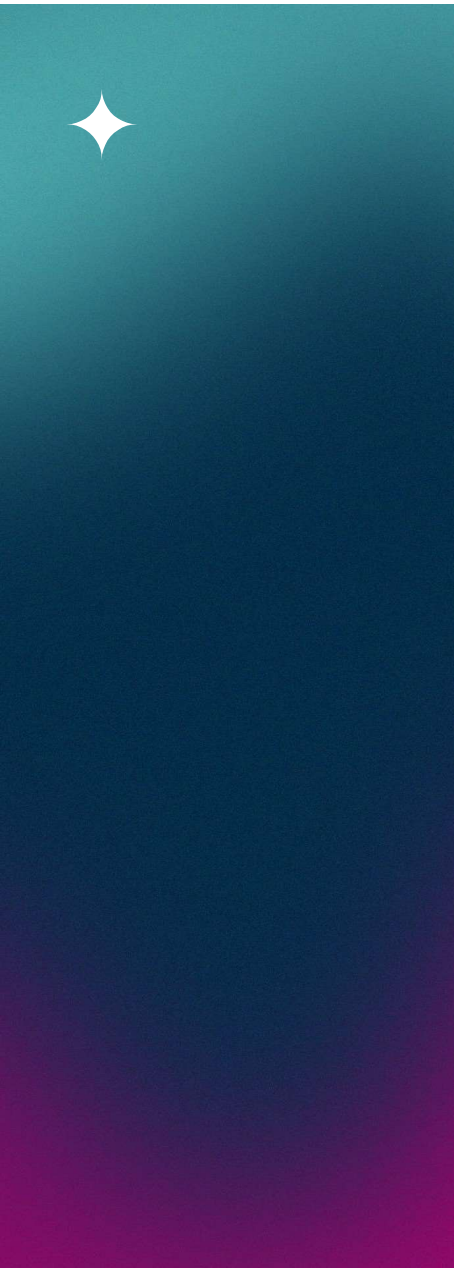


Yearly meeting 2023 (Darmstadt, Germany).



Yearly meeting 2024 (PSI & ETHZ, Switzerland).





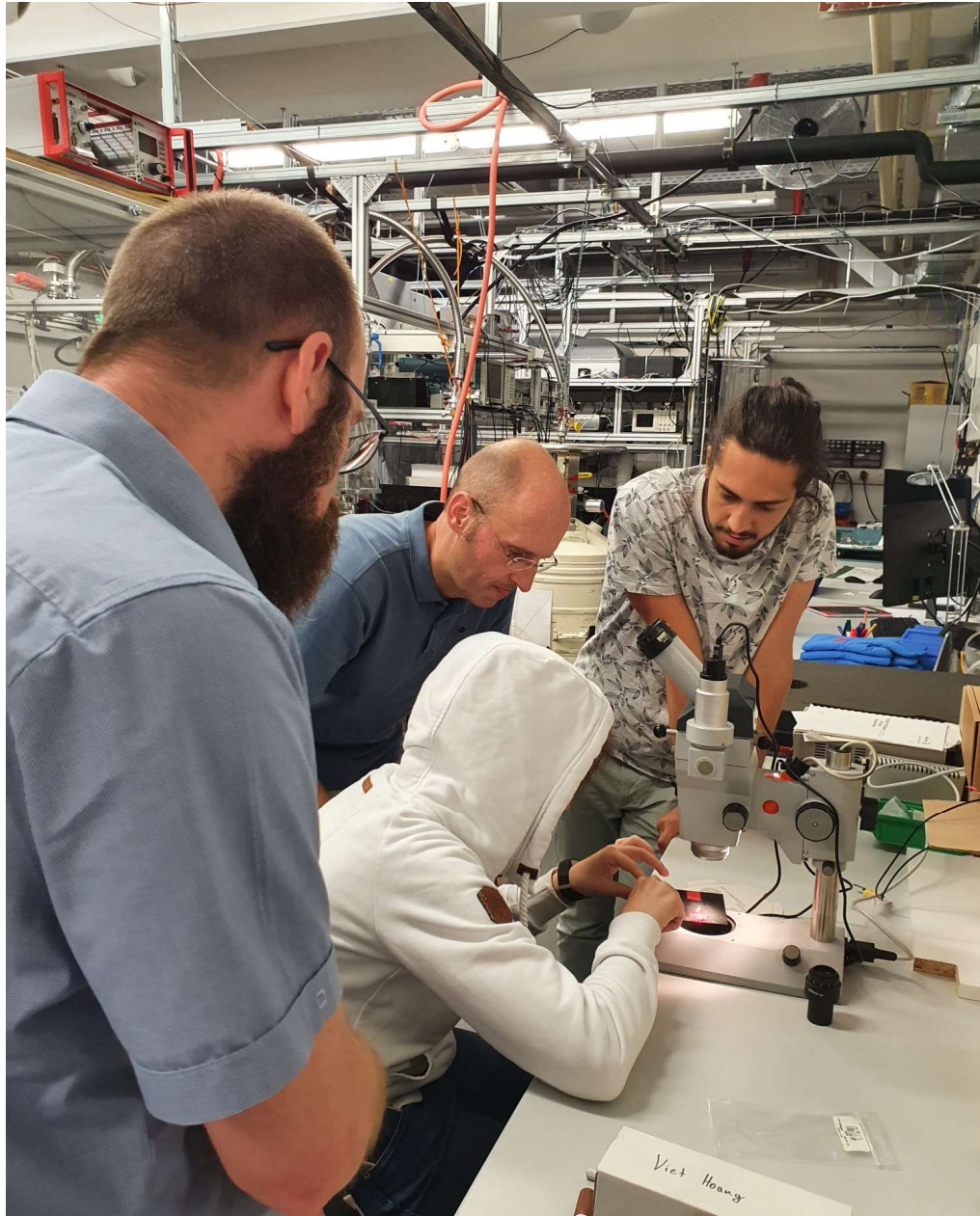
COLLABORATION (overview)



INFRASTRUCTURE SHARING within the project consortium

- TU Darmstadt acts as the central hub to distribute fibers (+ the expertise to handle them) to the entire consortium.
- Joint development of code to simulate atom trajectories
- Joint Mattermost channel for rapid exchange
- Joint development between PSI and AQT on atom sources

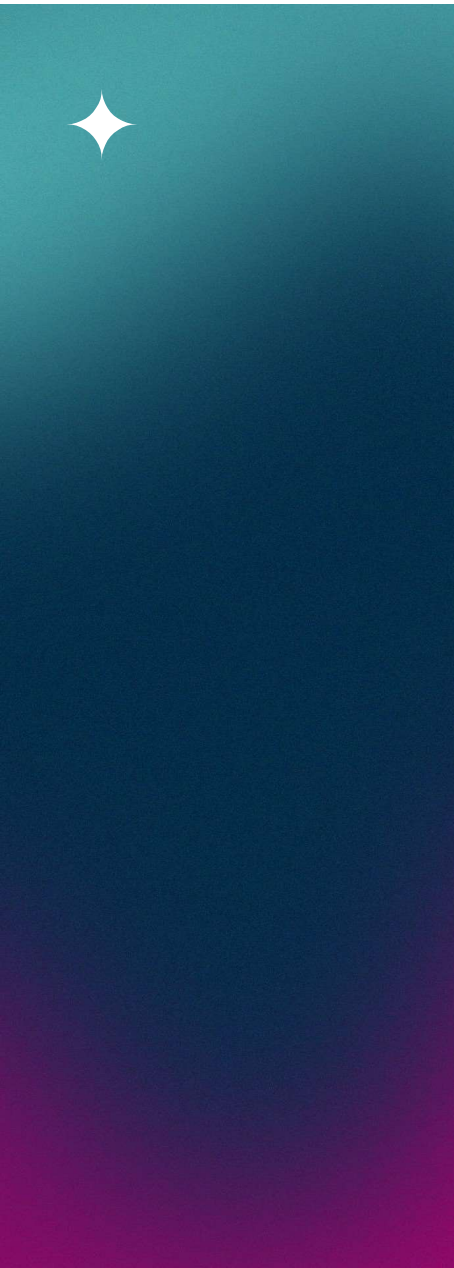




The essence of QuantERA

Thorsten Peters (group leader TU Darmstadt) training Jolan Tissier (PhD PSI), Anica Hamer (PhD Bonn) and Marcin Witkowski (ground leader Torun) to prepare hollow-core fibers.





SUCCESS STORY (highlights)



CHALLENGES and SOLUTIONS

Challenge 1

Loading of atoms into fibers has only been established with alkali atoms (Rb, Cs) thus far, but quantum computers and optical clocks require alkaline-earth-metal atoms.

Solution 1

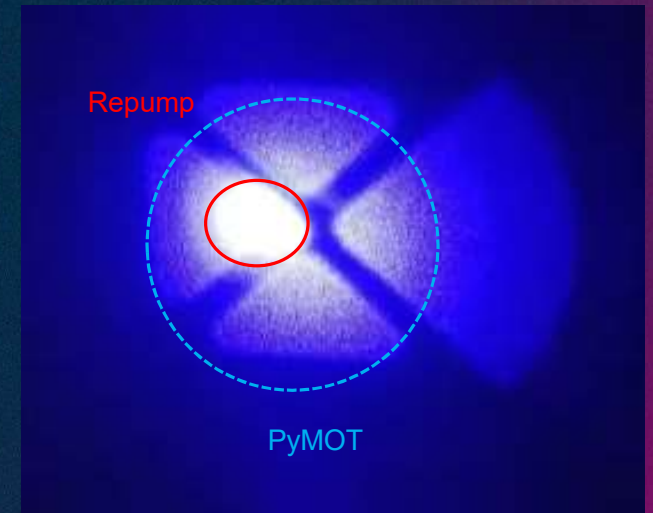
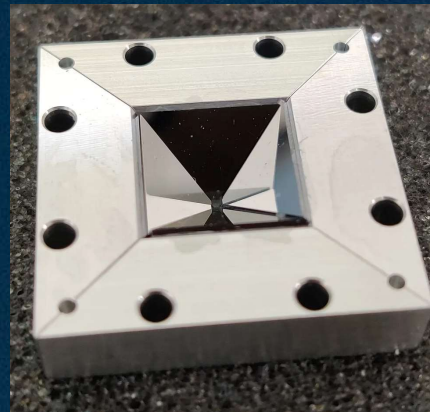
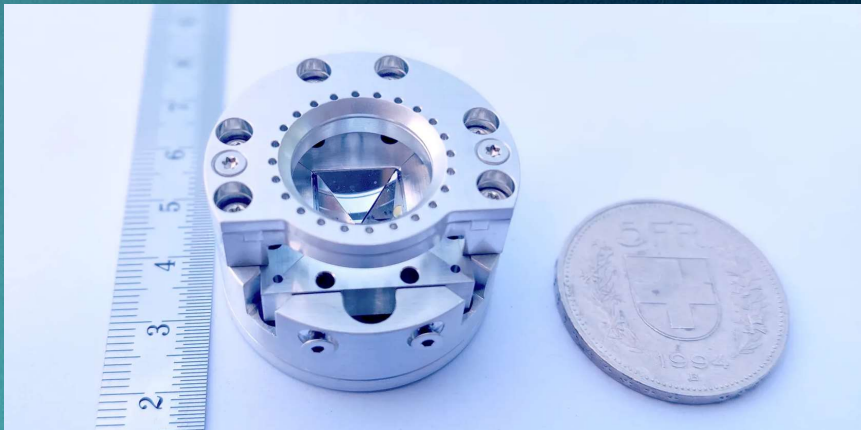
Set up two entirely new experiments: one in Torun for loading of Sr atoms into fibers, and one at PSI to develop a compact source of laser-cooled Ca atoms.

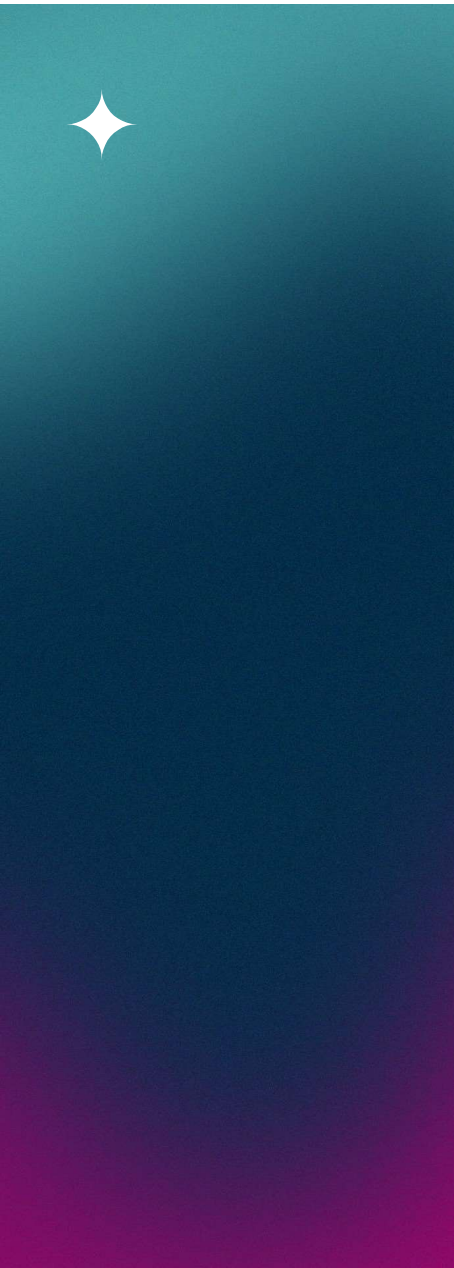




QuantumGuide highlight

miniaturized Ca MOT as a cold-atom source





SUCCESS STORY (highlights)



CHALLENGES and SOLUTIONS

Challenge 2

Increasing fiber length from a few centimeters to a few meters

Solution 2

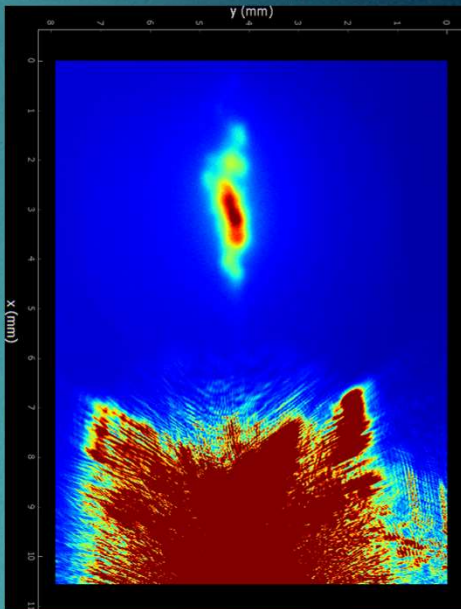
Understand atom loss and heating mechanisms within the fiber.



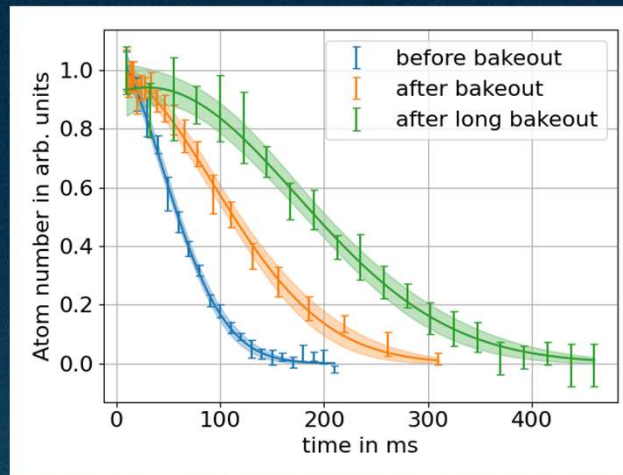


QuantumGuide highlight

understanding of heating and loss mechanisms

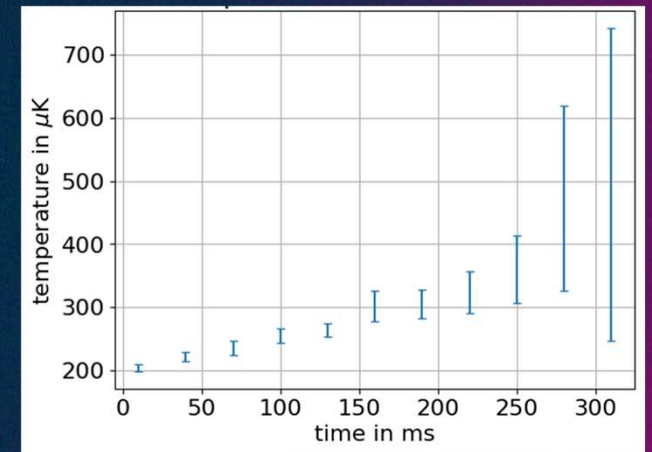


Laser-cooled atoms (top cloud) 3 mm above the tip of the fiber (scattered light below), just before loading

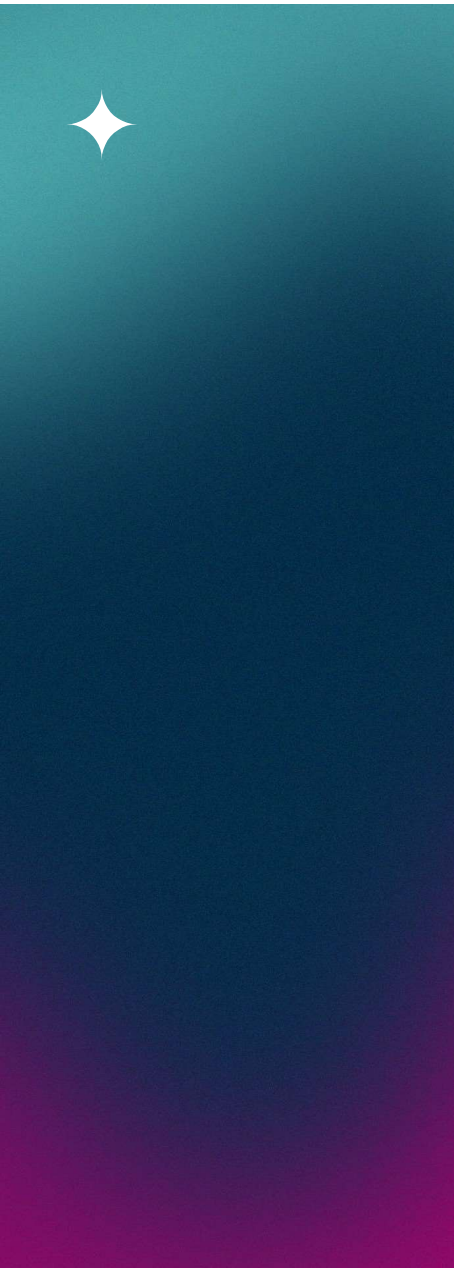


Lifetime in fiber can be increased to ~ 250 ms through baking of the fiber

For a lifetime of ~ 300 ms and a velocity of ~ 10 m/s, atoms can be transported over ~ 3 m.



Approximately linear heating rate over the first ~ 200 ms.



SCIENTIFIC OUTPUTS



PUBLICATIONS AND PRESENTATIONS (highlights)

6 peer-reviewed publications
among them two joined publications
more publications currently in preparation

Countless presentations and posters at conferences



NUMBER OF BACHELOR, MASTER AND PhD THESES

1 Master thesis
Viet Hoang

4 PhD theses finished (or finished soon)
Anica Hamer
Andreas Reuss
Marcus Malki
Jolan Tissier



IMPACT (potential users)



KEY COMMERCIALY RELEVANT **APPLICATIONS**

- Cold atom delivery for
 - Quantum computing and networking
 - Quantum sensing and metrology (clocks)
 - Fundamental few- and many-body physics



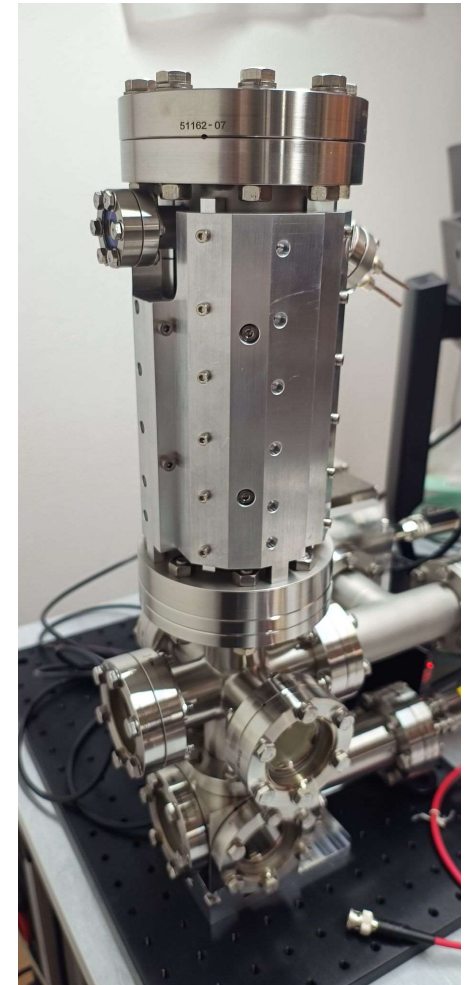
EXISTING/POTENTIAL **END USERS**

- Academic and industrial R&D labs
- Quantum technologies software and hardware vendors



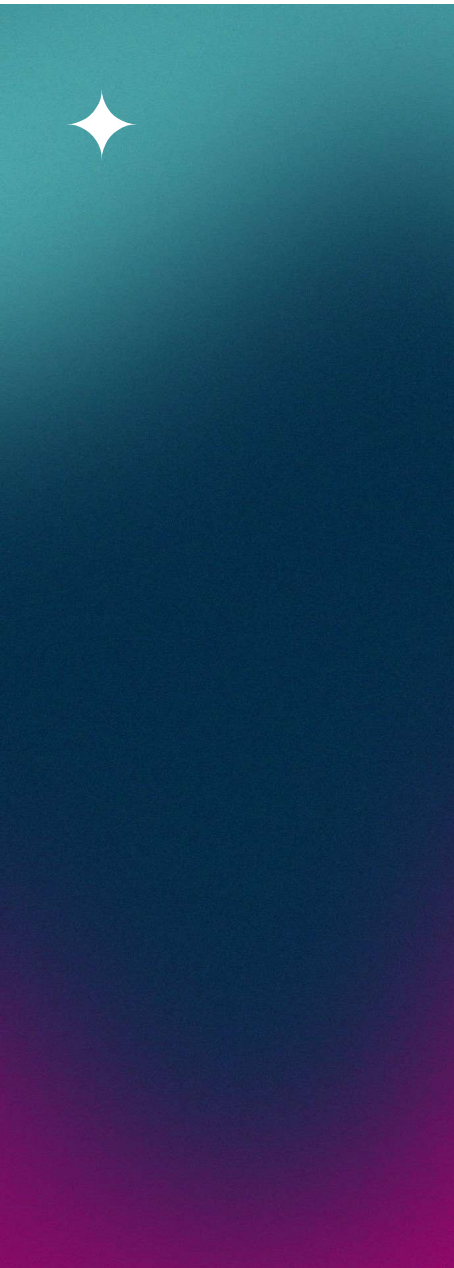
COOPERATION WITH THE **QUANTUM FLAGSHIP** OR OTHER QUANTUM INITIATIVES

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



Engineered 2D-MOT source for feeding the HCF



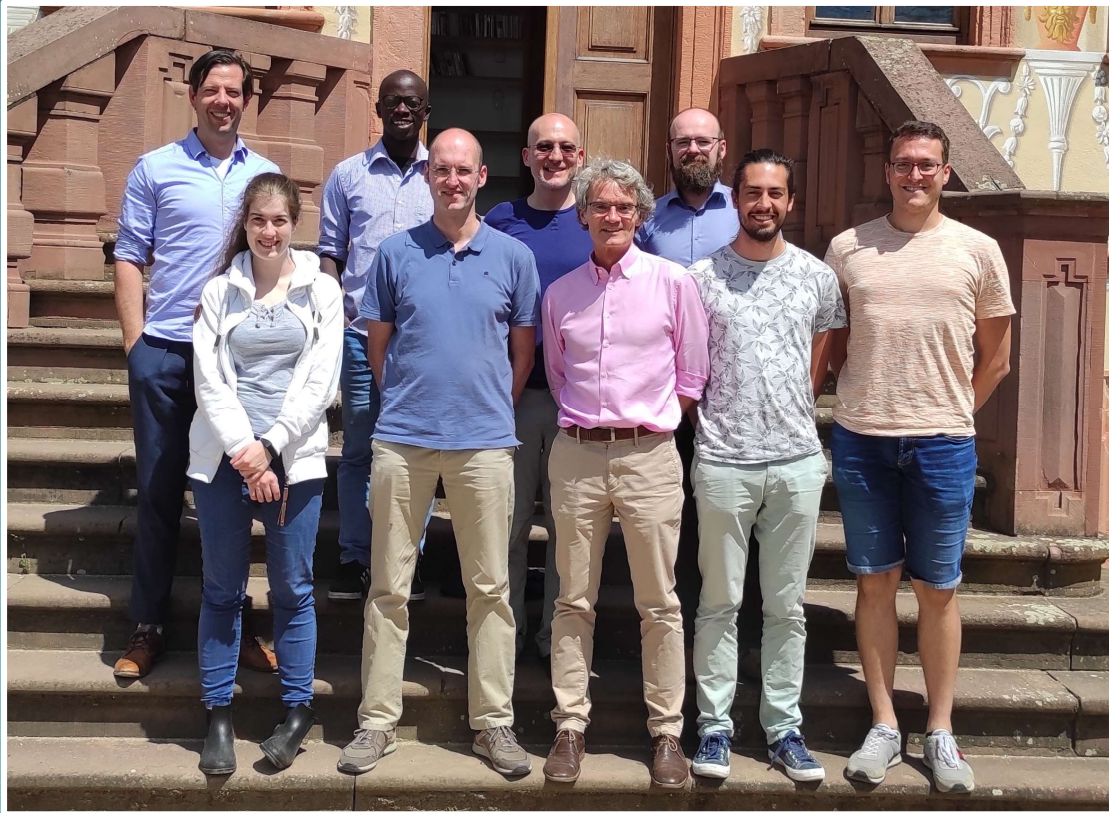


WHAT'S NEXT

No new application within the QuantERA 2025 call, but research will continue within other projects:

- Bonn: BMFTR project “VUV-goes-Quantum” to take light sources and hollow-core fibers into the VUV regime
- PSI & AQT: joint development work continues
- Torun: hollow-core fibers for feeding optical lattice clocks now within other projects
- AQT: successful proposal “FALCON” within the 2025 call





Uni Bonn

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AQT

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Tetsu Takekoshi
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Co-funded by
the European Union