



D 4.1

Quantum Summer School report



Status: Published

Version: 1

Date: 2024-12-30

DOCUMENT CONTROL SHEET

Work Package Number	WP4
Work Package Title	eduQUTE – International training and education centre for Quantum Technologies
Lead-Beneficiary	QUTE.sk
Work Package Leader	Pavol Surovec
Deliverable Number	D4.1
Relevant Task	T4.3
Participants	QUTE.SK, IP SAS, CU BA
Dissemination Level	Public
Due Date (Month)	M21
Authors And Contributors:	Diana Cencer Garafová, Pavol Surovec, Djeylan Aktas
Distribution:	skQCI members, EC

VERSIONING AND CONTRIBUTION HISTORY

Version	Date	Revisions	By	Status
V1	2024-10-24	First Draft	Diana Cencer Garafová, Pavol Surovec, Djeylan Aktas	Draft
V1	2024-12-30	Second Draft	Pavol Surovec	Draft
	2025-01-03		Pavol Surovec	Published

The project skQCI is funded by the EU Programme DIGITAL (101091548) and Programme NextGenerationEU from Recovery and Resilience Plan of the Slovak Republic (1789/2023).



**Funded by
the European Union**

**[RECOVERY
AND RESILIENCE]
PLAN**

DISCLAIMER

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Ministry of Investments, Regional Development and Informatization of the Slovak Republic. Neither the European Union nor the granting authority can be held responsible for them.

Table of Contents

QUANTUM SUMMER SCHOOL REPORT	1
DOCUMENT CONTROL SHEET.....	2
VERSIONING AND CONTRIBUTION HISTORY	3
BACKGROUND: ABOUT SKQCI PROJECT	5
INTRODUCTION	6
OBJECTIVES OF THE SUMMER SCHOOL.....	7
PROMOTING THE SUMMER SCHOOL	7
EVENT OVERVIEW	9
CURRICULUM AND CONTENT OVERVIEW	10
MORNING SESSIONS	10
AFTERNOON WORKSHOPS	11
HANDS-ON WORKSHOPS.....	11
OUTCOMES AND ACHIEVEMENTS	13
FEEDBACK AND PARTICIPANT IMPACT	13
CHALLENGES AND LESSONS LEARNED.....	13
CONCLUSION AND FUTURE PLANS.....	14
ACKNOWLEDGEMENTS	15
APPENDIX A.....	16

BACKGROUND: ABOUT SKQCI PROJECT

This project aims to develop a quantum communication infrastructure in Slovakia.

THREE MAIN ACTIVITIES:

1. The goal is to use the same hardware and technology for implementing various entanglement-based QKD protocols to populate, in this first phase, six nodes across Slovakia (later on another six nodes), thus **creating the backbone of a national quantum network**. The chosen approach will not only meet the criteria of this call for connecting several European cities with QKD links. Still, it will also lay the foundation for the next steps in achieving a quantum internet that goes beyond simple cryptographic tasks, allowing Slovakia to consider other quantum communication protocols in the future.
2. The objective of building this infrastructure within the duration of this project will also be accompanied by the development of **our own superconducting nanowire single-photon detectors and cryogenic systems**, which will help accommodate the needs of a growing quantum network beyond the timeline of this funded research.
3. The current project enables Slovakia to actively participate in the EuroQCI European mission by developing quantum communication technologies and helping **establish a training research center** that will benefit the whole Central-European territory, creating a sustainable knowledge-based ecosystem for future quantum engineers.

As part of this initiative, an effective Communication, Dissemination, and Exploitation Plan is essential to promote awareness, encourage collaboration, and ensure the successful implementation of project objectives. This plan outlines the strategies and activities that will be employed to engage different target groups of the community, disseminate project results, and exploit the outcomes for broader societal and economic benefits. Later, the project results should be exploited for academic and non-academic purposes.

Introduction

The Quantum Technologies Summer School represents a pivotal step in the ongoing efforts to advance quantum technologies education and foster international collaboration within the quantum ecosystem in Central European countries.

After establishing contact with FH Technikum Wien, the concept of organizing joint quantum technology summer schools was developed. The inaugural joint summer school with international participation took place in Vienna from August 21-25, 2023. FH Technikum Vienna was the main organizer, with several members of the skQCI consortium actively contributing to the preparation and execution of the event.

After last year's edition in Vienna, the Quantum Technologies Summer School 2024 successfully took place in Bratislava. This event, held from August 19-23, 2024, at the Faculty of Mathematics, Physics, and Informatics (FMFI), Comenius University in Bratislava, brought together a global community of students, researchers, and industry experts for an immersive educational experience.

The summer school was co-organized by the Institute of Physics, Slovak Academy of Sciences (IP SAS), QUTE.sk – Slovak National Center for Quantum Technologies, and FH Technikum Wien, with the support of Comenius University Bratislava (CU BA). It aimed to provide participants with a blend of theoretical insights and hands-on experience in quantum computing, cryptography, and electronics, preparing the next generation of scientists and engineers for the rapidly evolving quantum technologies sector.



Objectives of the Summer School

The Quantum Technologies Summer School 2024 aimed to achieve the following objectives:

PROMOTE EDUCATION IN QUANTUM TECHNOLOGIES

To deepen participants' understanding of quantum mechanics and its applications in quantum computing, quantum communication, and quantum cryptography.

FOSTER INTERNATIONAL COLLABORATION

To bring together international participants from diverse academic and professional backgrounds, enhancing cross-border collaboration and knowledge exchange.

PROVIDE HANDS-ON LEARNING EXPERIENCES

To offer participants hands-on exposure to quantum technologies using state-of-the-art tools and equipment.

BRIDGE ACADEMIA AND INDUSTRY

To showcase the intersection of theoretical research and real-world applications by involving industry leaders in the program.

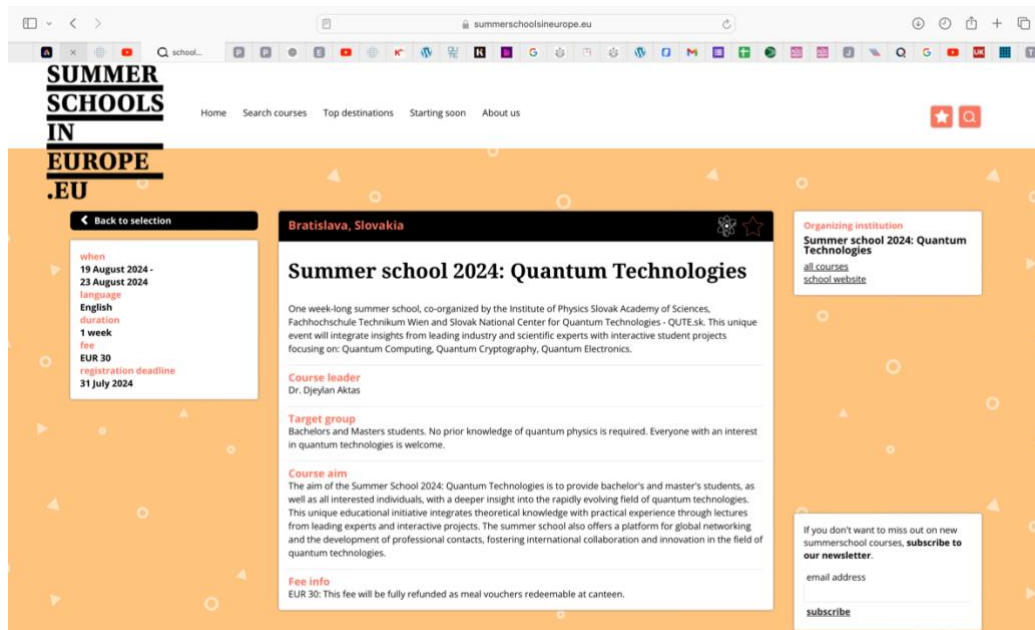
The event successfully met these objectives, providing participants with a comprehensive understanding of quantum technologies and equipping them with practical skills for future research and careers.

Promoting the Summer School

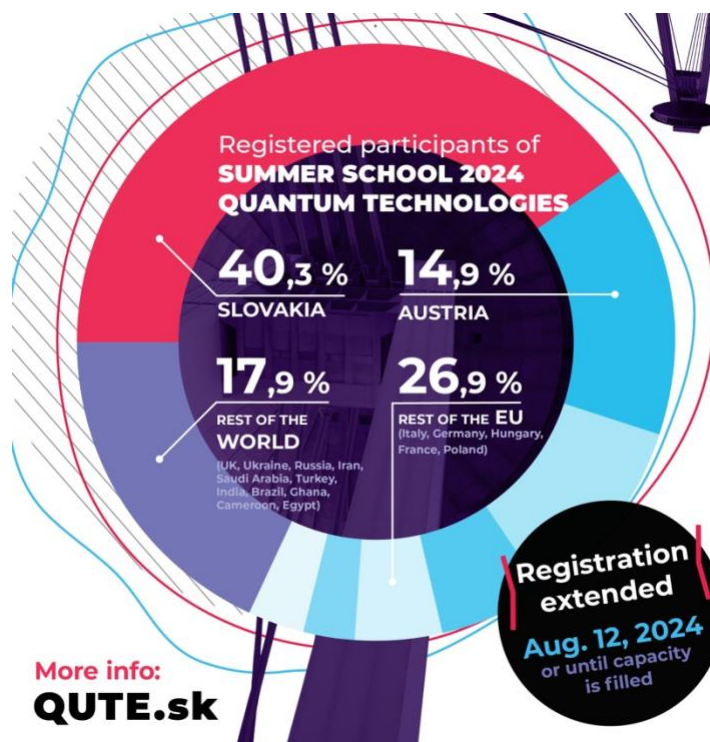
A comprehensive digital strategy was implemented across multiple platforms to promote the summer school. The project webpage served as the primary hub for detailed program information, registration, and updates. Other web pages and social media channels were used for engaging content to build awareness and drive interest.



Additionally, listings on www.summerschoolsineurope.eu ensured the program reached a wider international audience, attracting students seeking academic summer opportunities in Europe. These combined efforts maximized visibility and participation.



In total, **74 participants registered** for the summer school from different parts of the world:



Event Overview

Event Dates: August 19-23, 2024

Location: Faculty of Mathematics, Physics, and Informatics, Comenius University, Bratislava, Slovakia

Organizers:

Institute of Physics, Slovak Academy of Sciences (IP SAS)

QUTE.sk – Slovak National Center for Quantum Technologies

FH Technikum Wien

in cooperation with:

Comenius University Bratislava (CU BA)

Participants: 52 international participants (See *Appendix A* for Attendance list), including PhD students, young researchers, and early-career professionals from around Europe and beyond.



Curriculum and Content Overview

The summer school offered an intensive curriculum combining theoretical lectures and practical workshops to provide participants with both foundational and advanced knowledge in quantum technologies.

Morning Sessions

Academic and industry leaders presented lectures on theoretical concepts and practical applications of quantum technologies, including topics in quantum computing, quantum cryptography, and quantum electronics.

Notable speakers from **qtLabs**, **Single Quantum**, **AIT**, **Aricoma**, **Accenture**, and **IBM** shared insights into cutting-edge developments in the field.



Afternoon Workshops

Hands-on workshops using state-of-the-art equipment, allowing participants to directly engage with quantum technologies and perform experiments.

KEY TOPICS

Quantum Computing: Introduction to quantum circuits, quantum gates, and quantum algorithms such as Grover's algorithm and the BB84 protocol.

Quantum Cryptography: Focus on Quantum Key Distribution (QKD) and secure communication protocols.

Quantum Algorithms: Quantum algorithms and the quantum gates used to build them, including mathematical foundations necessary for understanding quantum logic gates.

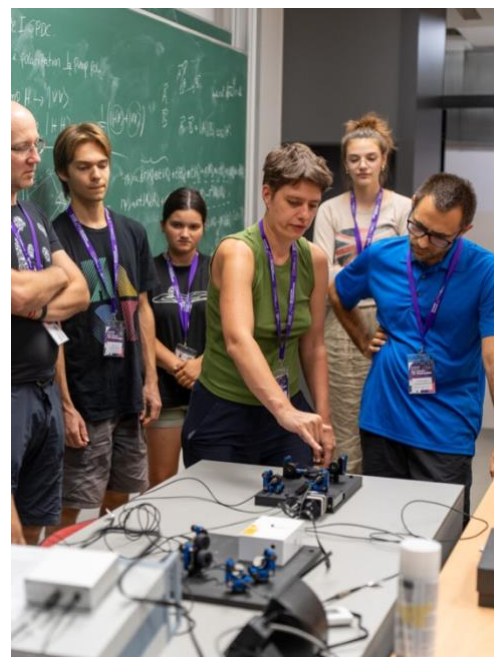
Hands-On Workshops

The summer school featured a series of hands-on workshops, each focused on practical engagement with quantum technologies, ensuring that participants gained direct experience in experimental and computational quantum physics.

Workshop Groups

GROUP 1 & GROUP 2: EXPLORING QUANTUM PHENOMENA WITH THE QUED DEMONSTRATOR

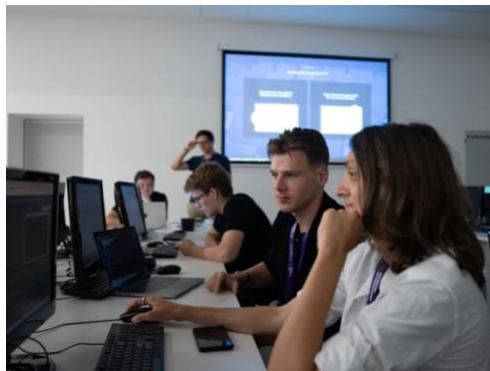
Participants explored foundational quantum experiments, including Bell's Theorem and Quantum Key Distribution (QKD), using the quED Entanglement Demonstrator. The workshops provided insights into quantum entanglement and secure communication protocols.





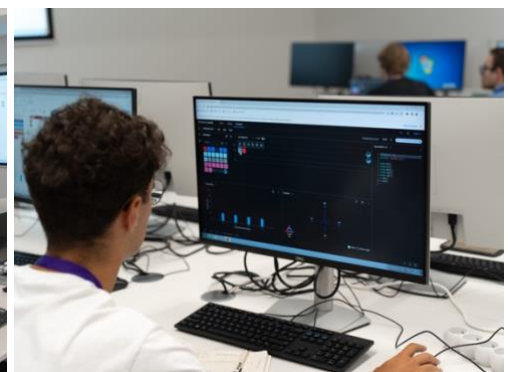
GROUP 3: QUANTUM COMPUTING WITH INDUSTRY EXPERTS

Guided by professionals from Aricoma and IBM, this group worked with the Gemini Mini Pro, a real desktop quantum computer, to explore quantum gates, circuits, and algorithms, using the Qiskit software to simulate real-world quantum algorithms.



GROUP 4: QUANTUM ALGORITHMS AND ADVANCED GATES

Focusing on advanced quantum algorithms, such as Grover's algorithm and Bernstein-Vazirani algorithm, participants gained a deep understanding of how quantum logic gates impact quantum states and how to program and execute these algorithms on quantum computers.



Outcomes and Achievements

ENHANCED QUANTUM EDUCATION

Participants gained in-depth knowledge of quantum mechanics, cryptography, quantum computing, and quantum communication, and developed practical skills in implementing quantum algorithms and conducting quantum experiments.

HANDS-ON EXPERIENCE

The workshops allowed participants to interact with cutting-edge quantum technologies, such as the quED Entanglement Demonstrator and the Gemini Mini Pro quantum computer, and experience quantum phenomena firsthand.

INTERNATIONAL COLLABORATION

The summer school fostered international cooperation, with participants and speakers from diverse backgrounds, including both academic institutions and leading tech companies.

FUTURE RESEARCH AND CAREERS

The program equipped participants with skills applicable to ongoing research in quantum technologies, providing them with the tools to contribute to the evolving quantum ecosystem.

KNOWLEDGE DISSEMINATION

Educational materials are available to all participants for further learning.

Feedback and Participant Impact

Feedback collected from participants highlighted the following key takeaways:

The hands-on workshops were particularly valued because they allowed students to **interact directly with quantum hardware** and experiment with real quantum systems.

Participants appreciated the **interdisciplinary approach**, which combined theoretical depth with practical insights into industry applications.

The event helped participants **build connections with industry** leaders, enhancing their career prospects in quantum technologies.

Challenges and Lessons Learned

DIVERSE BACKGROUNDS

With participants coming from varied academic backgrounds, there was a need for careful balancing of the curriculum to ensure accessibility for both beginners and more advanced learners.

BALANCED PROGRAM

The strength lies in connecting theoretical knowledge with practical experience, helping participants see the real-world and tangible applications of what is often perceived as an abstract and complex field.

Conclusion and Future Plans

The Quantum Technologies Summer School 2024 was a resounding success, achieving its goals of advancing quantum education, fostering international collaboration, and providing participants with hands-on experience in quantum technologies. It helped bridge the gap between academia and industry, preparing the next generation of quantum professionals to tackle the challenges of this emerging field.

Looking ahead, the Quantum Technologies Summer School 2025 will build upon this success, with plans to expand the program, increase international participation, and include more advanced topics in quantum science and technology. Efforts will also focus on further enhancing the collaboration between academic institutions and industry players to ensure that the curriculum remains aligned with the latest advancements in quantum technologies.

As mentioned earlier, the **Quantum Technologies Summer School 2025** will be held **in Vienna**, following the tradition of cooperation between IP SAS and FH Technikum Wien.



Acknowledgements

We would like to extend our sincere gratitude to the following organizations and individuals for their contributions to the success of the summer school:

FH Technikum Wien for its partnership in organizing the event and providing logistical support.

Comenius University Bratislava for hosting the event and offering the venue.

Institute of Physics, Slovak Academy of Sciences and QUTE.sk for their organizational efforts and expertise in quantum technologies.

All involved industry partners for their invaluable contributions through workshops and expert guidance.

Appendix A



WHEN: August 19 - 23, 2024
WHERE: FMFI, Comenius University, Bratislava
ORGANISER: IP SAS, FH Technikum Wien, QUTE.sk

List of attendance

Prince		
Hossein		
Abdullah		
Thomas		
Eleonora		
Emil		
Mohammadali		
Peter		
Oleksii		
Peter		
Alexandra		
Nunzio		
Raffaele		
Domenico		
Federico		
Emma		
Leonardo		
Vít		
Lea		
Max		
Marie Luise		
Nora		
Martin		
Windholz		
Alica		
Filip		
Anna		
Adrian		
François-Elie		
Gabriele		

Stefan		
Anna		
Marcin		
Ivan		
Serhii		
Ömer Faruk		
Matej		
Marek		
Vladimir		
Dániel		
Martin		
Marko		
Abdel M. Njikam		
Ivan		
Marko Timotej		
Ijaz Ahamed		
Matej		
Ádám		
Faithful Ineoma		
Praveen		
Hanka		
Rastislav		
Nicolas		
Emil		
Luíza		
Soham		
Federico		
Daniela		
Vadym		
Vincenzo		

Summer school 2024: Quantum Technologies



WHEN:
WHERE:
ORGANISER:

List of attendance

[illegible][illegible]



WHEN: August 19 - 23, 2024
WHERE: FMFI, Comenius University, Bratislava
ORGANISER: IP SAS, FH Technikum Wien, QUTE.sk

List of organisers / tutors

Djeylan		C
Younes		
Daniel		
Vladimír		
Diana		
Hermann		
Ivan		
Gilberto		
Mariana		
Seyed Arash		
Miroslav		
Zora		
Leevi		C
Lukas		
Mira		
Branislav		
M. Hamed		
Jessie		
Peter		
Saeid		
Pavol		
Mário		
Kristína		
ONDŘEK		
Michael		
Nico		