

# FUNDING INITIATIVE QUANTUM AUSTRIA

INTERIM REPORT 2024



$$i\hbar \frac{\partial}{\partial t} \psi(r,t) = \left[ -\frac{\hbar^2}{2m} \Delta + V(r,t) \right] \psi(r,t)$$



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## IMPRINT

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Georg-Coch-Platz 2, 1010 Wien, [www.fwf.ac.at](http://www.fwf.ac.at)

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# FUNDING INITIATIVE QUANTUM AUSTRIA

## INTERIM REPORT 2024

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# Views of Quantum Austria



Austria has taken a world-leading role in quantum research. This success is underscored by Quantum Austria. The initiative exemplifies the importance of publicly funding basic research in highly innovative areas and in key technology fields to facilitate innovation and strengthen Austria as a business location. Joint implementation by the FWF and FFG is exemplary in this regard. The diverse projects, from basic to applied research, serve to make Austria and Europe more competitive in this research field over the long term.

Martin Polaschek,  
Federal Minister of Education, Science and Research



Quantum technology has become a strategic topic in today's world and the long-term investments made today will lay the foundations for sustained benefits in the future. Just as a Nobel Prize builds on decades of – at times unrecognised – work, so does Austria's – and in fact Europe's – future position in the quantum field depend on the sustained strategic investments made today.

The Quantum Austria Initiative is such a strategic investment. As its Strategic Advisory Board, we have been closely engaged with the initiative since its inauguration and we particularly welcomed the diversity of its funding portfolio resulting in an inclusiveness for all areas related to Austria's quantum research. This inclusiveness has already paid in terms of the diversity of the 55 projects funded and the impact that they will generate. Quantum Austria further enhances the visibility of Austria's 70+ quantum research groups both within the field and the broader society.

With the integration of fundamental research and its applications, Quantum Austria is thus pushing the field further ahead, building on and enhancing the unique potential of Austria's quantum research landscape. As the funding for this initiative now has been allocated and the calls closed, we strongly encourage all concerned parties to plan ahead in terms of sustained strategic investments to safeguard Austria's leading role in quantum research.

Mari Carmen Banuls, Glinos Konstantinos, Dieter Kranzlmüller, Michael Marthaler and Christine Silberhorn,  
Quantum Austria Strategic Advisory Board



Thanks to the FFG's Quantum Austria funding programme and the HPQC (High-Performance Quantum Computing) project, Math.Tec can expand its expertise in quantum computing in a targeted manner and combine its current skills in conventional optimisation with the potential offered by quantum technology. We work closely with academic project partners to research and develop hybrid optimisation solutions that are geared to meeting specific industry and logistics requirements. Without the support of the Quantum Austria HPQC project, we would not be able to combine existing scientific knowledge with practical challenges, to test the entire range of hybrid quantum computing technology, and develop innovative technological approaches.

Karl Knall, Math.Tec GmbH



The Quantum Austria Funding Initiative is a successful example of FFG and FWF cooperation. As our international review procedure has shown, Austrian quantum researchers are already at the global forefront of work in this field. Investments in promising fields through formats such as Quantum Austria are important to maintain this leading position over the long term. At the same time, society benefits twofold from these investments: they not only generate knowledge but also have a positive impact on value creation.

Christof Gattringer, President of the FWF



Austria's researchers are pioneers in quantum research. In the Quantum Austria initiative launched by the Ministry of Science, the FFG joins forces with the FWF to strengthen infrastructure and R&D projects in this key technology of the future and facilitate leaps in innovation.

FFG Managing Directors  
Henrietta Egerth and Karin Tausz



The second quantum revolution – the breathtaking development of modern quantum science – would not have been possible without the groundbreaking and Nobel Prize-winning contributions from Austria. For a long time, however, it was difficult to finance the expensive instruments needed. This has left us falling behind other countries. Fortunately, funds from the EU Recovery Fund, financed under the Quantum Austria initiative of the Austrian Science Fund (FWF) and the Austrian Research Promotion Agency (FFG), have been supporting such research infrastructure since 2022. This allows us to advance fundamental research in the quantA Cluster of Excellence and many other projects. This is the only way to make future innovations possible.

Gregor Weihs,  
Director of Research quantA – Quantum Science Austria



# The QUANTUM AUSTRIA Funding Initiative

The Austrian Research Promotion Agency (FFG) and the Austrian Science Fund (FWF) are implementing the Quantum Austria Funding Initiative (Qu-AT) from 2021 to 2026. The initiative is carried out on behalf of the Federal Ministry of Education, Science and Research (BMBWF) and is financed by the European Union under the **NextGenerationEU Recovery and Resilience Plan** (2020–2026). Austria is using funding from the Recovery and Resilience Plan (RRP) to invest EUR 107 million into developing quantum research and technologies. The aim is to stimulate research, development and innovation activities in the field of quantum research and technology, and to maintain competitiveness, in line with the research, technology and innovation policy objectives of the Austrian Federal Government. Funding will go towards both basic research and the development of practical applications.

Following the strategic guidelines of the RRP, Austria's national research funding institutions – the **Austrian Science Fund (FWF)** and the **Austrian Research Promotion Agency (FFG)** – are tasked with implementing the programme using approved and coordinated funding formats. The FFG and FWF are working closely together on allocating funding and using a selection of their respective funding instruments for personnel and infrastructure. Part of the funding is earmarked for research infrastructure for use in next-generation high-performance computing, quantum computing, and their intersections.

Funding is provided for projects with clearly defined goals, methods, durations and financing volumes, in accordance with the conditions of the respective funding agency. Applications must address topics of quantum research and quantum technology. The research questions may include, for instance, the following topics:

- Specific preparation and control of quantum states;
- New algorithms and mathematical theoretical concepts that exploit the superposition and entanglement of quantum states;
- Developments and applications in quantum communication; quantum sensor technology, quantum

metrology, quantum simulation, quantum computing and quantum information;

- Development of ideas based on quantum phenomena in the neighbouring fields of physics, mathematics, chemistry, and in biological systems.

## Strategic goals

The strategic goals of the Quantum Austria initiative are to position Austria as a leading player in the field of quantum technologies. This includes promoting innovative research, products and services based on significant advances in quantum research in recent years. Novel approaches to spreading quantum research fields beyond established ideas should become possible, particularly in light of the sustained and long-term effect of the initiative. Quantum Austria offers a unique opportunity to support high-risk projects with high profit potential.

The initiative is designed to enable the Austrian research community to actively participate in European programmes and support the EU's digital transformation goals. Its particular focus lies in using quantum science for innovative products and services, and to support European technological sovereignty in quantum technologies. Another key aspect is to adapt according to European developments in high-performance computing, and to integrate quantum technologies in the context of **HPCQS** and **EuroQCS**, for example. Consequently, the initiative not only reflects the (main) objectives of the Austrian RRP, but also the National Strategic Roadmap for the Austrian Digital Decade<sup>1</sup>.

The initiative also aims to intensify investment in basic research for quantum technologies in order to facilitate the use of the technology in specific applications and products. The initiative encourages Austrian research groups to network at both national and European level, ensuring they achieve the critical mass required for competitive innovation structures. Undertaking pioneering research and development projects and establishing modern infrastructure will promote future-oriented digital and innovative research and support the green and digital transformation.

<sup>1</sup> In the context of and for the implementation of: *Europe's Digital Decade: digital targets for 2030 (European Commission)*; [https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/europes-digital-decade-digital-targets-2030\\_en](https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/europes-digital-decade-digital-targets-2030_en)

## Operational objectives

The initiative will further enhance the leading role of Austrian research groups in basic research, as well as early-stage technology development in the field of quantum technologies. A central concern is to intensify investment in basic research and to support the transfer of research findings to specific applications, products, systems, and services. This is to be achieved through targeted funding measures, which simultaneously support strategic networking between research groups at national and European level, allowing them to achieve the critical mass required for competitive innovation structures.

The initiative also aims to facilitate forward-looking, digital research through innovative research and development projects and by establishing a modern quantum and high-performance computing (HPC) infrastructure. This makes equal support for hardware and software development essential as the two areas are closely linked. Efficient software solutions not only help reduce the energy footprint but also are also crucial for the optimal use of modern hardware, ultimately enhancing the competitiveness and innovative strength of Austria's research landscape.

## Target groups

The Quantum Austria Funding Initiative allows researchers, universities, non-university research institutions and companies working in quantum research and technology to select from existing FFG and FWF funding programmes. Cooperation between the two funding

agencies ensures the availability of a wide range of funding options for researchers at universities, universities of applied sciences, and non-university research institutions, as well as for R&D activities conducted by start-ups, businesses, and industry.

## Objective of the interim report

This interim report is a mandatory requirement for the implementation of the Austrian Recovery and Resilience Plan. The report is a milestone in the implementation of the Quantum Austria initiative and has been drawn up in accordance with the Council Implementing Decision using the available project data. It presents the progress achieved to date in the Calls, as well as in the projects where possible.

The following sections also describe how the individual elements of the measure description contained in the Council Implementing Decision, have been and will be implemented.

The objectives of the initiative have been described in the first part of this report; the following sections present the governance of the initiative, the Call deliverables, the Calls themselves and their respective approvals, and finally their current visible impact as well as ongoing projects.

This content is supplemented by information boxes, presented in colour to distinguish them from the body of the report. These information boxes contain examples of initiatives, measures and additional data showing how Quantum Austria is embedded within Austria's RTI system.

## Quantum Engineering made in Austria

Master's degree programme: Quantum Engineering | UAS Technikum Wien



Significant progress has been made in quantum research and the development of quantum technologies in recent years. Quantum Austria is expected to contribute to this progress in Austria. Engineers have the expertise to drive this progress, developing ideas in laboratories to benefit society as a whole.

In response, the new Quantum Engineering Master's degree programme will start at UAS Technikum Wien in the winter semester 2024/25. As part of the **2024/25 expansion of the universities of applied sciences, UAS Technikum Wien has been awarded federal funding for 20 student places to establish this new and innovative Master's degree programme at the interface between laboratories and applications.** The new programme meets the need for appropriate engineering qualifications in the labour market. This follows the shift in demand from quantum technology researchers to engineers. The programme is aimed at holders of a Bachelor's degree in physics, electronics, computer science, or engineering. Working in cooperation with industry, the programme produces highly qualified engineers able to develop hardware for quantum communication systems and quantum sensors, programme quantum computers, implement systems for quantum cryptography, or work in photonics using coherent light.

# Bodies of the initiative

**A**s a first step, two bodies were established to steer the initiative: the Steering Committee charged with steering tasks, and the Strategic Advisory Board (SAB) acting in an advisory role. The Steering Committee acts as the gateway between the Federal Ministry of Education, Science and Research (BMBWF) as the initiative's contracting entity for the FFG and the supervisory authority for the FWF, and

is responsible for operational control of the Quantum Austria funding initiative. Both FFG and FWF, under the chairmanship of the BMBWF (Departments V/3 and V/9), are represented on the Steering Committee at programme manager level. The previous activities of the Steering Committee and the Strategic Advisory Board are summarised below.

## Activities of the Steering Committee

Table 1: Meetings of the Steering Committee to date

1 <sup>st</sup> meeting	20/07/2022	Inaugural meeting, adoption of the rules of procedure
2 <sup>nd</sup> meeting	10/10/2022	Status of Calls (FWF and FFG), funding requirements, budget transfers between FFG and FWF
3 <sup>rd</sup> meeting	11/04/2023	Status of Calls and processing (FWF and FFG), proposals for 3rd FFG Call
4 <sup>th</sup> meeting	15/09/2023	Financing of the 'Quantum Science Austria' Cluster of Excellence, transfer of funds between FFG and FWF, planning for the 3rd FFG Call
5 <sup>th</sup> meeting	14/06/2024	Planning for repurposing administrative funds as operational funds at the FFG, planning of 4th FFG Call, milestone fulfilment

The inaugural meeting of the Steering Committee was held in July 2022, adopting the rules of procedure drawn up with the participation of the FFG. The second meeting followed in October 2022. During this meeting the current status of the Calls was presented, and opportunities for further Calls identified. Following the recommendation of the Steering Committee, the distribution of operational funds between the FWF and FFG was adjusted in favour of the FFG. As it was possible to award a further EUR 10 million in funding, four projects from the 1st Call's reserve list received funding approval.

Two Steering Committee meetings were held in 2023. The third Steering Committee meeting, in April 2023, served to discuss the status of the Calls processed by the two agencies and further Call planning. The additional funding requirement announced by the FWF at this meeting was due to the partial funding of the 'Quantum Science Austria' Cluster of Excellence from Qu-AT funds, and the

parallel and continuing large volume of applications to the other FWF funding programmes used in Quantum Austria. At the fourth meeting in September 2023, EUR 2.55 million of uncommitted FFG funds were reallocated to the FWF on the recommendation of the Steering Committee.

The last meeting of the Steering Committee to date was held in June 2024. The main topic was the optimal use of the RRF funds still available with respect to planning a 4th FFG Call. The FWF presented the last open review as of June 2024 – and thus also the final budget of the FWF. The FFG also presented an update of the estimated use of administrative funds, along with a proposal to reallocate unused administrative funds as operational funds, for use in the agreed 4th Call. Finally, the initiative's two open milestones were discussed: the present interim Quantum Austria report scheduled for December 2024, and the completion of all projects in the first quarter of 2026.

## Activities of the Strategic Advisory Board

Table 2: Meetings of the Strategic Advisory Board to date

1 <sup>st</sup> Meeting	19/11/2021	Inaugural meeting, election of the spokesperson, the initiative's objectives and funding instruments
2 <sup>nd</sup> Meeting	11/07/2022	Technology areas eligible for funding, funding of high-risk projects, transfer of basic research findings to industry
3 <sup>rd</sup> Meeting	06/11/2023	Presentation of a few already funded projects, discussion, and recommendations for remaining Calls
4 <sup>th</sup> Meeting	09/12/2024	<i>In planning, perspective for Quantum Austria after Calls concluded</i>

Three meetings of the initiative's Strategic Advisory Board have been held since the start of the initiative. The fourth meeting is scheduled for December 2024.

The first meeting on 19 November 2021 was held to constitute the Strategic Advisory Board and elect its Chair and Vice-Chair. The initiative's objectives and framework conditions as well as the available funding instruments were also discussed. The members of the Strategic Advisory Board underlined how the diversity of the available funding instruments ensured low-threshold access to the initiative, and noted in particular how projects seeking funding should include educational and training measures to develop quantum computing and the quantum research location.

At the second meeting on 11 July 2022, the significant number of high-risk projects in the initiative was highlighted as a positive factor. Questions were raised about knowledge retention in Austria and possible gaps in the funded research landscape. Furthermore, options for funding as early as the application phase were discussed, which the FWF felt would be of particular interest to young researchers. The interface between research and industry was noted as a particular challenge. In response, three possible strategies were proposed: (1) supporting the best groups in Austria; (2) identifying specific national gaps so that they can be closed through strong cooperation at European level; (3) and integrating basic research and industry. The Strategic Advisory Board recommended that the FFG and FWF support these processes by organising joint events for universities, research institutions, and industry partners as a means of networking interested stakeholders. Two of these networking meetings had already been held at the time of this interim report. Two further networking meetings are due to be held as part of the *2025 International Year of Quantum Science and Technology* (<https://www.quantumscience.at/quantum2025>).

The third meeting of the Strategic Advisory Board was held in Vienna in November 2023. In addition to the reports from the FWF and FFG, three projects were invited to present their past and future activities – FWF: Cluster of Excellence 'Quantum Science Austria'; FFG: R&D Infrastructure Project **MUSICA** (Multi-Site Computer Austria, Call topic 2); and Flagship Project **HPQC** (High-Performance Integrated Quantum Computing, Call topic 1). The Strategic Advisory Board discussed and drafted possible recommendations for the outstanding funding based on these presentations and emphasised the importance of sustainable infrastructure funding – also outside the Quantum Austria Initiative – for establishing and maintaining Austria's successful research networks in this field.

The fourth meeting is scheduled for December 2024. This meeting will discuss the interim report on the initiative as well as the perspectives for Austrian quantum research following the end of the last Quantum Austria Call.

# Call implementation of the initiative

The Calls of the initiative were implemented in accordance with the relevant guidelines and agreements, in particular the FFG's **Special Directive** and the FWF's **1st Development Agreement for Quantum Austria 2021–2023** and 2nd Development Agreement on the Financing Agreement 2021-2023. The FWF and FFG are working closely together to implement the funding initiative, and coordination meetings were and are held as required.

Both agencies use existing funding instruments to implement the Calls. Changes required due to the particular characteristics of the Quantum Austria initiative were laid out in the relevant Call guidelines. The Calls were implemented in accordance with the needs of the research landscape, and the consulting services offered by both agencies were proactively enhanced by means of information events. Individual consulting was provided via various channels including telephone, email, video conferences, etc. The projects were selected based on the procedures and bodies put in place by the two agencies (**Funding Law and Finances** (FFG), **General Principles of the FWF Decision-Making Procedure**).

Independent international experts are involved in the review process. The funding decisions for FFG projects were made by the BMBWF, and for the FWF by the FWF Board. Following the decisions of the FWF Board, the projects were compared with those of the FFG and, on a quarterly basis, with the transparency database as well as the EU databases Kohesio, ERC dashboard and Financial Transparency System, in order to reveal any potential instances of multiple funding.

The funding agreements for all FFG Calls closed by July 2024 were signed and the first instalments paid out as per the relevant guidelines. The first interim reports have

already been submitted in 21 projects and 5 more are pending. The FFG examines the content of the interim reports using standard procedures and checks the submitted accounts and the project's progress on a regular basis. Further instalments are paid following successful completion of these checks. The FFG processes include managing, checking, and taking any necessary measures against multiple funding, conflicts of interest and fraud detection. The FFG's internal control system oversees the implementation and suitability of the various checks and is itself subject to regular audits by the responsible European and national bodies.

Funding agreements were signed for the FWF projects approved in the reporting period and funding paid out in accordance with the relevant draw down requests (ad-personam projects according to § 26 UG) or instalment schemes (project funding via research institutions § 27–28 UG). The annual accounts must be presented by 30 April or submitted via the Austrian Federal Computing Center (BRZ) interface. In accordance with its obligation to demonstrate the results and impact of the funded research and to ensure that the funding has benefited the research community and society in general, the project managers of ongoing projects are required to enter published research results into the FWF's research documentation system on an annual basis. Once a project has been completed, the research results, information on statistical and programme-specific issues, as well as changes to the original project plan are recorded and made publicly available through the **FWF Research Radar**. The FWF also supports the Quantum Austria Funding Initiative through public relations, in the 'scilog' magazine, and its media cooperation with the Austrian public radio station Ö1 on its "Was die Welt zusammenhält" programme.

## Agency collaboration framework

2022 saw the finalisation of the basic documents necessary for the implementation of the initiative (Special Directive Quantum Austria, implementation agreement; GZ: BMBWF 2022-0.186.121); the drafting of the FFG cooperation agreement with the FWF; and the inauguration of the Steering Committee. Furthermore, an FFG information event was held on 3 February 2022 to present the initiative. 84 participants had registered for this webinar in advance.

With the conclusion of the 2nd Development Agreement for the Financing Agreement (FV) 2021–2023 in June 2023, the Financing Agreement (FV) 2021–2023 and the **1st Development Agreement for Quantum Austria 2021–2023** were amended in accordance with § 7 (11) in conjunction with § 5 (8) of the Research Financing Act (FoFinaG, Federal Law Gazette I No. 75/2020). As a result, the programmes for Quantum Austria were expanded to include the Excellence Initiative and the Clusters of Excellence as well as partial funding up to a funding rate of 60% for the Cluster of Excellence (COE) 'Quantum Science Austria'.

A cooperation agreement, together with a sideletter and a supplementary agreement to the cooperation agreement, was concluded between the two funding agencies FFG and FWF to define the framework conditions for joint implementation of the initiative. Under these agreements, the contracting parties have created the option of reallocating funding budgets under the conditions specified in the agreements in order to best meet the needs of the research community. This option is granted in the implementation agreement with the FFG and in the FWF's development agreement with the BMBWF. In 2022 and 2023, this option was used twice on the recommendation of the Steering Committee. The 2022 annual report already described a reallocation of EUR 10 million to the FFG.

The FFG and FWF implemented their respective Calls throughout the entire period up to the reporting date (31 July 2024). These operational activities are presented below.

## Operational activities

The FFG uses several project types (funding instruments) for the implementation of the Quantum Austria initiative. They include established instruments with minor adjustments made to the framework conditions, such as project duration and submission eligibility.

The Calls are assigned to the two key topics of the initiative<sup>1</sup> (in accordance with the Austrian Recovery and Resilience Plan):

- Topic 1 – Research Cooperation and R&D Infrastructure (incl. Flagship Project)
- Topic 2 – HPC Infrastructure Update and Transfer to Regular Operations

Quality assurance in the selection of projects submitted to FFG Quantum Austria Calls is carried out in accordance with established procedures and standards (see the FFG evaluation manuals, <https://www.ffg.at/content/die-bewertungshandbuecher-der-ffg>). Submitted proposals are assessed by an evaluation committee composed of internationally recognised experts, set up according to established FFG processes. The committee draws up a list of project applications recommended for funding which is then submitted to the BMBWF. The BMBWF is charged with making the final funding decision based on this list.

After the launch of the initiative, the FFG opened its first two Calls in 2021 and 2022, implementing them by the end of 2022. In the first Call, the FFG offered a variety of funding instruments: Individual Projects of Industrial Research; Cooperative R&D projects; R&D Infrastructure; and BRIDGE Knowledge Transfer as part of the 35th BRIDGE Call (<https://www.ffg.at/ausschreibung/bridge-35-ausschreibung-bridge-1>). The second Call focused on R&D infrastructure for the interface between quantum and high-performance computing. Most of the projects approved in these first two rounds of FFG Calls started work in 2023. As late as 2023, the BMBWF launched a third Call via the FFG which ended on 29 February 2024, and subsequently a fourth Call with a deadline of 19 August 2024. Both were dedicated to the topic of highly security-relevant quantum computers using multi-valued logic. The FFG used the Oriented Basic Research instrument for this purpose, again providing funding to support the implementation of excellent high-risk projects. Only the first of the last two Calls has already been approved by the BMBWF; the contracts have been signed and the projects commenced. As of the reporting date, approval is still pending for the FFG's final Call. Details of the Calls are presented below.

Applications for Quantum Austria projects could be submitted to the following FWF programmes by the deadline of 30/06/2024: Principal Investigator Projects, Erwin Schrödinger Fellowships, Early-Stage Programme: Research – Innovation – Training (ESPRIT), 1,000 Ideas Programme, and Clusters of Excellence. The FWF used existing funding programmes of the **FV 2021–2023** Financing Agreement for the Quantum Austria Calls. The requirements for submitting an application were in line with the relevant requirements for existing FWF programmes and the **Supplementary Application Guidelines for the Funding Initiative**. The last applications for Principal Investigator Projects and Erwin Schrödinger Fellowships including a return phase required the project duration to be adapted to the term of the initiative.

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<sup>1</sup> All FFG calls can be found at <https://www.ffg.at/en/quantum-austria>.

The Call documents were provided on the [Subject-Specific Funding page](#) on the FWF website. Approved Quantum Austria projects and their scientific output are continuously available on the [FWF Research Radar](#) page. The key data and links to the funding initiative are also summarised on the FWF webpage "[In the Spotlight: Quantum Austria](#)".

In addition to the agencies' primary task of implementing the initiative, both have already organised two events for the community at the suggestion of the Strategic Advisory Board. As well as exchanges between science and industry as the name suggests, these *Quantum Austria networking meetings* have given researchers the opportunity to present their ongoing projects.

The first networking meeting for the research community, jointly organised by the FFG, FWF and BMBWF, was held on 30 November 2022. The event was aimed at organisations, research institutions and researchers who are actively involved in Quantum Austria projects or interested in participating. The programme included presentations on topics including quantum computing, quantum communication, patents, and quantum sensing. A forum for Quantum Austria project pitches as well as a networking section offered the more than 80 participants the chance to meet and talk about current quantum technologies and potential collaborations.

The second networking meeting was held on 13 November 2023, organised by the FWF and FFG in cooperation with the Federation of Austrian Industries (IV), and titled "Key Technologies Forum: Industrial Applications for Quantum Technology". In the light of Quantum Austria, the event was used to outline and discuss the possibilities and opportunities arising from the use of quantum technology in industrial applications. A total of 123 participants and two online speakers took part.

A third networking meeting was originally planned for 16 September 2024, as a prelude to the 20th anniversary celebrations of the Institute of Quantum Optics and Quantum Information in Innsbruck. However, following heavy rainfall and flooding of the railway line between Vienna and Innsbruck, the event was cancelled at short notice. An alternative date is scheduled for spring 2025.

# Calls and approvals (to July 2024)

## FFG Calls and project funding

Due to the initial budget restrictions, in 2022 it was not immediately possible to fund all recommended projects in the first two Calls. Due to the positive response to the Calls, during the second meeting of the Steering Committee, further budget was released for the first two FFG Calls by reallocating funds from the FWF to the FFG. Thus, in 2023 the last remaining project on the reserve list from the first Call received its funding commitment. As a result, it was possible to approve all projects recommended for funding from the first and second Calls.

in quantum computing. There is a particular focus on projects which address the research and development of highly security-relevant quantum computers using multi-valued logic. This Call closed on 29 February 2024. For this Call, too, all projects recommended for funding were able to commence their activities by the deadline. Following the strong response to the third Call, a further Call for the same topic was launched on 18 July 2024. This Call was still open as of the reporting date.

The Call documents were/are made available on the [programme webpages](#).

The third Call was launched on 22 December 2023 and is dedicated to projects involving basic research

### Overview of Quantum Austria Calls carried out by FFG:

1st Call			
Launch	15/12/2021		
Indicative budget	€39.2m Topic 1: €19.2m Topic 2: €20.0m	R&D Projects HPC Infrastructure	Requested funding: €64,740,486 €20,000,000
Submission deadlines	Topic 2, R&D Infrastructure Topic 1, Bridge	1 submission 0 submissions	€20,000,000
30/03/2022			
27/04/2022 (Topic 1)	Individual Project of Industrial Research (IR) Cooperative R&D Project R&D Infrastructure	5 submissions 7 submissions 12 submissions	€2,938,954 €11,412,584 €40,878,673
31/05/2022 (Topic 1)	Flagship Project	2 submissions	€9,510,275
<b>Total</b>		<b>27 submissions</b>	<b>€84,740,486</b>
Evaluation committees		Funding recommendation	Max. funding
12/05/2022	Topic 2 – R&D Infrastructure	1 project	€20,000,000
13/06/2022	Topic 1 – Cooperative R&D Project	5 projects	€7,797,536
14/06/2022	Topic 1 – R&D Infrastructure	9 projects	€27,189,382
15/06/2022	Topic 1 – Individual Project (IR)	4 projects	€2,319,045
13/07/2022	Topic 1 – Flagship Project	1 project	€4,374,061
<b>Funding recommendation</b>		<b>20 projects</b>	<b>€61,680,024</b>
2nd Call			
Launch	05/10/2022		
Indicative budget	€9.0m (allocated to Topic 1, R&D Infrastructure)		
Submission deadline	25/11/2022	3 submissions	Requested funding €11,049,214
<b>Evaluation committee</b>	<b>14/12/2022</b>	<b>Funding recommendation</b>	<b>Max. funding</b>
<b>Funding recommendation</b>		<b>1 project</b>	<b>€8,999,279</b>

### 3rd Call

Launch	21/12/2023		
Indicative budget	€5.0m (allocated to Topic 1, Oriented Basic Research)		
Submission deadline	29/02/2024	6 submissions	Requested funding €8,226,142
Evaluation committee	09/04/2024	<b>Funding recommendation</b>	<b>Max. funding</b>
<b>Funding recommendation</b>		<b>5 projects</b>	<b>€3,969,554</b>

### Summary – Calls 1 to 3

Projects submitted	36
Total funding requested	€104,015,842
Projects recommended for funding	26
Total funding recommendation (max.)	€74,648,857
<b>Total costs of the projects recommended for funding</b>	<b>€78,560,280</b>

### 4th Call

Launch	18/07/2024
Indicative budget	€5.0m (allocated to Topic 1)
Submission deadline	19/08/2024

### BMBWF funding decisions (up to 31/07/2024)

<b>Approved projects and funding</b>	<b>26</b>	<b>€74,648,857</b>
R&D Infrastructure	11	€56,188,661
Individual Project (IR)	4	€2,319,045
Cooperative R&D Project	5	€7,797,536
Flagship Project	1	€4,374,061
Oriented Basic Research	5	€3,969,554
<b>Participations (number of project partners)</b>	<b>67</b>	
Universities	37	€61,918,500
Research organisations	13	€5,868,293
SMEs	11	€5,935,125
Large enterprises	5	€586,854
Other	1	€340,085
Of which total international partners	6	€1,090,377

## FWF Calls and project approvals

Since the start of the Call, the FWF has received a total of 67 Quantum Austria project submissions for the following funding programmes: Principal Investigator Projects, ESPRIT, Erwin Schrödinger, 1,000 Ideas, and Clusters of Excellence. This represents an application volume of EUR 42.8 million from Austria's universities, the Austrian Academy of Sciences (ÖAW) and the Institute of Science and Technology Austria (ISTA). Nine approval rounds were conducted until the reporting date of 31 July 2024. Due to the excellent scientific quality of the submissions, funding was granted to a total of 30 projects worth EUR 22.8 million carried out at research institutions (principal investigator) in Graz, Innsbruck, Linz, and Vien-

na, as well as two foreign universities (Erwin Schrödinger Fellowships). This corresponds to a current funding volume of EUR 22.6 million, taking into account a project transfer and supplementary approvals, e.g. for inflation adjustments and child allowances. One research project was transferred to the German Research Foundation (DFG) in accordance with the **Money follows Researcher** rule. The withdrawn funds were made available for other Quantum Austria funding approvals. Two other projects (application volume EUR 810,200) were still under review as of the reporting date.

As of the reporting date of 31 July 2024, the approval rate by number of applications was 46%.

The decision of the Steering Committee allowed part of the Quantum Austria funds to be invested in the FWF Cluster of Excellence 'Quantum Science Austria', which aims to decipher the mysteries of the quantum world. With more than a hundred researchers at several locations, the Cluster of Excellence is one of Austria's largest cooperative research projects. The scientists in Innsbruck, Vienna, Linz and Klosterneuburg pose innovative, elementary questions in quantum science that

can only be solved by combining the unique expertise available in Austria. The Cluster of Excellence allows the research groups to further intensify collaboration and establish an internationally recognised centre of quantum sciences in Austria in accordance with the strategic aims of the initiative.

Details and figures on the Calls are shown in the following tables.

#### Overview of Calls carried out by FWF:

##### FWF Calls

Launch	26/11/2021	Indicative budget Topic 1:	€20.66m
Submission deadlines	Programme	Submissions	Requested funding
30 June 2024	Principal Investigator Projects	42	€16,349,541.95
	Erwin Schrödinger Fellowships including a return phase	7	€1,021,142.50
30 August 2022	ESPRIT Programme	11	€3,548,625.50
	<b>1,000 Ideas Programme (TAI)</b>	6	€874,873.50
	Clusters of Excellence	1	€21,000,000.00
<b>Total</b>		<b>67 submissions</b>	<b>€42,794,183.45</b>

Board meetings	Project approvals	Funding amounts
88th Board Meeting, May 2022	2 projects	€588,031.96
89th Board Meeting, June 2022	8 projects*	€2,513,253.17
90th Board Meeting, October 2022	8 projects	€2,646,294.09
91st Board Meeting, November 2022	4 projects	€1,674,368.98
92nd Board Meeting, March 2023	2 projects	€13,422,240.00
93rd Board Meeting, May 2023	2 projects	€811,985.31
95th Board Meeting, October 2023	1 project	€236,859.06
96th Board Meeting, November 2023	2 projects	€652,051.56
98th Board Meeting, April 2024	1 project	€206,652.88
<b>Approved projects</b>	<b>30 projects</b>	<b>€22,751,737.01</b>

\* One Principal Investigator Project was transferred to the German Research Foundation (DFG) in accordance with the Money follows Researcher rule; the associated funds were withdrawn.

##### Summary of Calls

Projects submitted	67
Total funding requested	€42.8m
Approved projects	30
Under review	2
<b>Total approved project funding as at reporting date after withdrawal of funds and supplementary approvals (for projects already approved)*</b>	<b>€22.6m</b>

\* Supplementary approvals include, e.g., inflation adjustments and child allowances. The balance between this amount and the indicative budget is met by reallocations made by the Steering Committee.

##### FWF funding decisions (up to 31/07/2024)

<b>Approved projects and funding after withdrawal of funds and supplementary approvals (for projects already approved)</b>	30	€22,638,473.84
Principal Investigator Projects	18	€6,555,950.93
ESPRIT Programme	7	€2,361,660.58
Schrödinger Programme	2	€410,238.79
1,000 Ideas Programme	2	€310,623.54
Clusters of Excellence*	1	€13,000,000.00

\* Partly funded from Quantum Austria; balance is financed from the FWF budget.

Participating research institutions*	Number of participations* in FWF projects
Universities	36
Non-university research institutions	5

\* Multiple participation possible.

## Indicators according to the CID Annex (jointly for FFG and FWF)

A total of 56 excellent, pioneering, transformative and innovative projects of basic and applied research are receiving funding under the Quantum Austria initiative.

Element i	Number	Funding amount
Projects of basic research*	35	€26,608,027.84
Projects of industrial research	10	€14,490,642.00
R&D infrastructure projects	11	€56,188,661.00
<b>Total</b>	<b>56</b>	<b>€97,287,330.84</b>

\* In addition to the definition in the Quantum Austria Special Directive, this category not only includes all approved FWF projects, but also projects funded under the FFG instrument 'Oriented Basic Research'. This funding instrument is designed for projects that have the potential to create the prerequisites for practical applications.

The projects funded by the FFG include 5 projects of oriented basic research and continue to invest in 21 research infrastructures (including software development) and research collaborations, with the aim of expanding the knowledge base for the (further) development of quantum computing, quantum simulation, quantum communication, quantum optics, quantum

sensor technology, quantum metrology and fundamental quantum developments. The 30 projects funded by the FWF comprise a total of 59 thematic contributions\*\* designed to establish or develop technologies for the entire field of quantum science in the above areas as well as in the field of quantum information.

Element ii	Number of FFG projects	Funding amount FFG	Number of FWF projects**	Allocated** funding amount FWF	Total number of contributions
Quantum computing	14	€44,631,441*	7	€13,669,615.55	21
Quantum simulation	2	€3,550,862	10	€15,219,369.96	12
Quantum communication	4	€4,115,544	3	€12,558,728.63	7
Quantum optics	1	€3,999,626	9	€3,168,093.54	10
Quantum sensor technology	2	€6,109,983	4	€12,660,079.35	6
Quantum information			10	€15,272,043.96	10
Quantum metrology	1	€3,251,634			1
Fundamental quantum developments	2	€8,990,767	16	€6,129,294.14	18

\* Including HPC Upgrade at €20m.

\*\* Projects of basic research (FWF) may be assigned to several categories.

# Impact

**A**t the time of this interim report, most projects have already started, with some already in their second project year. However, most of the final objectives have not yet been met. The progress of a few projects is presented in the following section, together with indicators that illustrate how Quantum Austria has already helped Austrian quantum companies and

start-ups to develop and realise their high quality and innovative power. In the first Quantum Austria Call alone, three applicants were encouraged to submit project applications for the first time. Their applications were of the highest quality, so that ultimately all of them secured funding.

## Quantum for Collaboration: Quantum research and technology in Austria



One of Austria's strategic goals is to catch up with the international leaders in RTI by expanding and ensuring access to research infrastructures.

Selected research institutions and research infrastructures in the field of quantum research and technology are made publicly visible and accessible via the research infrastructure database (*Open for Collaboration*). In the Quantum cluster, more than 100 research infrastructures for basic research and advanced research are already included (including a virtual map). Once established, funded Quantum Austria research infrastructures are gradually added to the research infrastructure database and, once operational, integrated into the publicly visible map. Consequently, the listed infrastructures extend far beyond those funded by Quantum Austria and offer an insight into Austria's existing expertise and potential for innovation in quantum research.

As a result, the research infrastructure database opens opportunities both to contact the research institutions as well as to use their research services or knowledge transfer for the purposes of innovation and technology development.

## International cooperation

With regard to cooperation with relevant European initiatives and projects, the FFG and FWF are also supervising applied research activities in the **QuantERA** programme. Furthermore, the FFG supports Austrian stakeholders in European formats such as Quantum Flagship, Horizon Europe, the Digital Europe Programme (including EuroQ-

CI), and the Connecting Europe Facility. Special mention should be made of the European Chips Act, which was introduced in 2023. The associated **Chips for Europe Initiative** also promotes the development of quantum chips, and Chips JU has already launched the first calls for quantum technology pilot lines. Austria is expected to participate in several of these technology platforms, especially in areas in which Austria is playing a leading role.

## Quantum technology patents: Austria in 3rd place among the EU-27



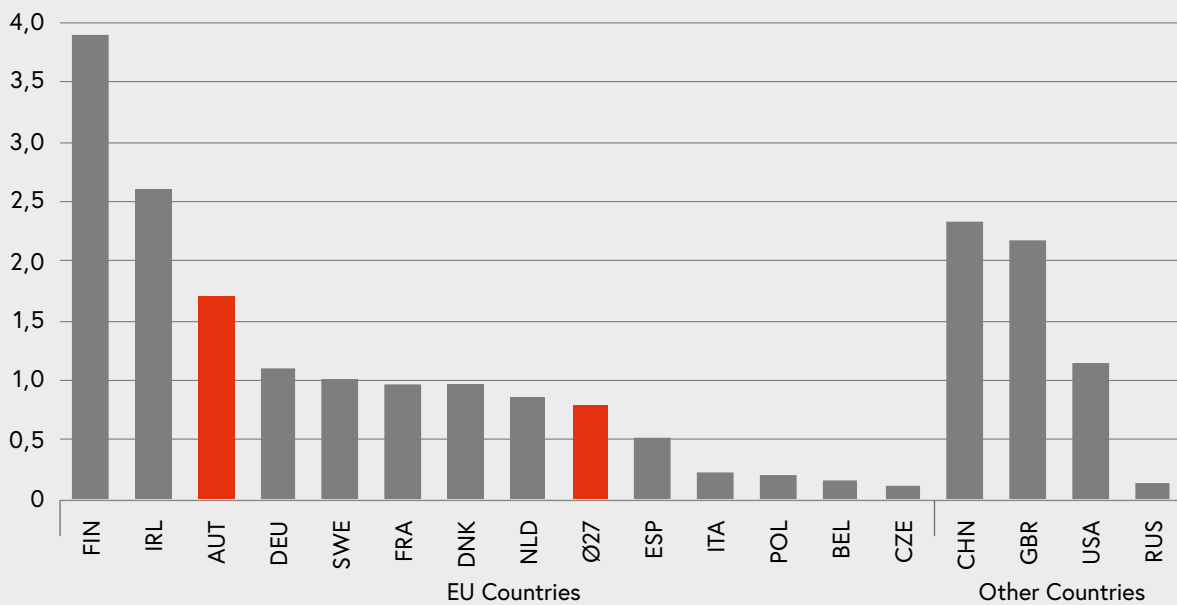
With 1.72 patent applications per 10,000 R&D employees, Austria takes third place in a country comparison based on 2021 data, after ranking eighth in 2020. This makes Austria one of the leading nations in the EU-27 country comparison, behind Finland and Ireland, which once again took the top places.

Figure 1 shows the number of patents across all four areas of quantum technologies per 10,000 R&D employees (measured in full time equivalents). As patent applications are usually published 18 months after the filing date at the European Patent Office, the year 2021 was chosen for the patent analysis.

For the patent analysis, Cooperative Patent Classification Codes (CPC codes) and keywords were used to filter out the patents displayed at the European Patent Office. CPC codes and keywords from four different areas of quantum research were used for the analyses, namely: quantum computing, quantum key distribution, entanglement, and cold atom interferometry.

Given the often lengthy patenting process, these figures are based on activities undertaken prior to Quantum Austria. It is to be expected that the figures for intellectual property rights related to Quantum Austria funding will continue to rise after the end of the initiative.

Figure 1: Number of patents for all fields of quantum technology per 10,000 R&D employees per country



In addition to these numerous points of reference, Quantum Austria is clearly strengthening cross-border cooperation with other countries in the European Union and beyond in many ways. This is exemplified by the following figures: Researchers in the initiative's FFG-funded projects work at a total of 17 university and non-university research centres in Austria and abroad, as well as in 14 companies (10 are SMEs). Now that all projects in the third Call have started with a total of 56 project participations (direct project partners), the FFG counts 6 funded

partners in other European countries. Furthermore, 3 of the SMEs are EIC Accelerator Grantees.

In contrast, the FWF-funded Quantum Austria projects enable a total of 130 researchers at 18 research centres in Austria and (for Erwin Schrödinger Fellows) abroad to work on fundamental questions in quantum science. They cooperate with colleagues in 56 other countries. At the time of the report, this had already resulted in 48 independent Open Access publications and 35 citations.

Element iii	Consortium partners in FFG projects	Collaborations in FWF projects
Australia		1
China		4
Germany	2	12
France	1	2
Great Britain		4
India		1
Ireland		1
Israel		1
Italy	1	5
Japan		2
Canada		2
New Zealand		1
Netherlands		1
Norway		1
Poland		1
Sweden		4
Switzerland	1	4
Serbia		1
Slovenia	1	
Spain		3
USA		5
<b>Total</b>	<b>6</b>	<b>56</b>

Figure 2: Global cooperations (incl. cooperation partners in FFG projects) within the Quantum Austria initiative

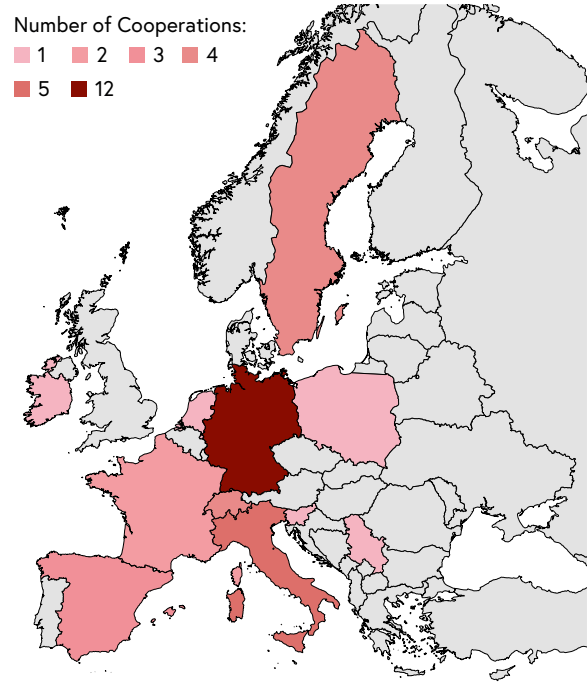
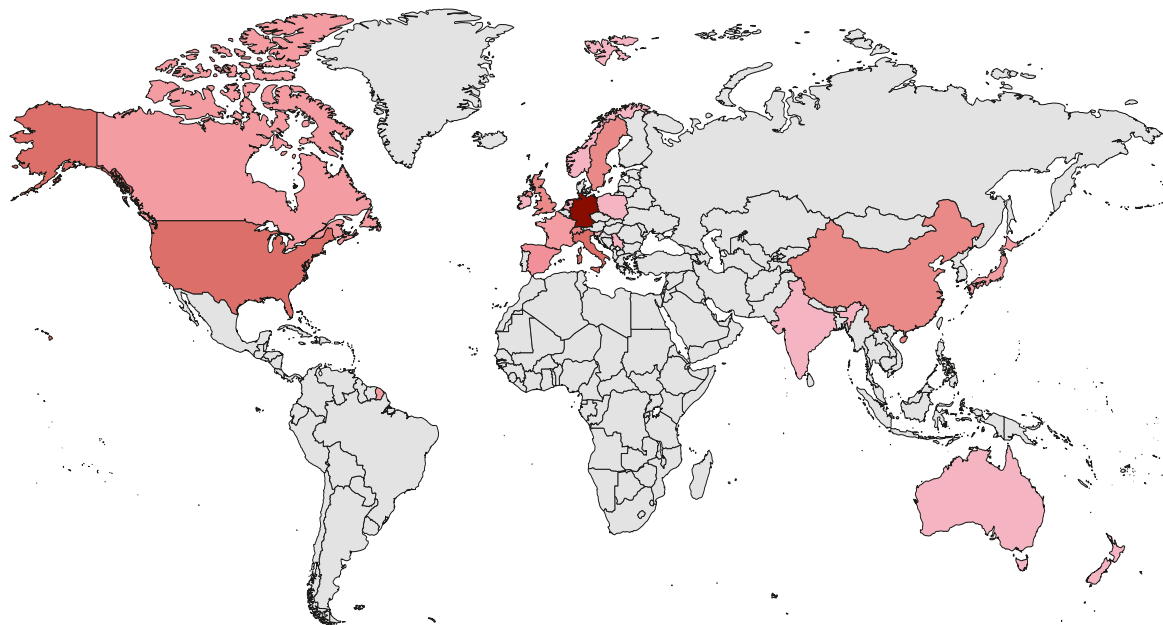


Figure 3: European cooperations (incl. cooperation partners in FFG projects) within the Quantum Austria initiative

Number of Cooperations: 1 2 3 4 5 12



Austria had (at least) 21 contractual participations in 10 Horizon 2020 quantum technology calls during the period 2014 to 2020. These can be assigned to 5 research institutions and 5 companies. All these organisations, with the exception of three companies, also submitted successful applications to the first three FFG Calls, and 4 of the research institutions made successful submissions to the FWF.

Since 2021, there have been 14 Cluster 4 calls (Digital, Industry and Space) under Horizon Europe related to quantum technologies with (at least) 39 contractual participations from Austria. These can be assigned to 7 research institutions and 5 companies. All these organisations, with the exception of one company, also submitted successful applications to the first three FFG Calls, and 6 of the research institutions also made successful submissions. Further mention should be made of the **EIC Pathfinder Challenge: Alternative approaches to Quantum Information Processing, Communication, and Sensing**. Two projects directly related to the content of this EIC initiative started in 2022; they are coordinated

between 3 Austrian universities and funded as Quantum Austria infrastructure projects.

Furthermore, the comparison with the European bottom-up programmes of the *Marie Skłodowska-Curie Actions (MSCA)* as well as all levels of personal *ERC Grants* is also remarkable. During the period 2014 to 2020 (Horizon 2020), 6 ERC grantees from Austria received FWF funding for 9 Quantum Austria projects, and 3 ERC grantees received funding for 4 FFG Quantum Austria initiative projects in the same period. For Horizon Europe, up to and including 2023, 6 ERC grantees (including 5 new ones) from Austria have successfully submitted 11 Quantum Austria projects to the FWF, and 3 ERC grantees are involved in 5 FFG-funded Quantum Austria projects. The research activities of 6 individual MSCA Fellowships in Horizon 2020 and one MSCA Fellowship in Horizon Europe to date have resulted in participations in 7 FFG Quantum Austria projects. Researchers have also been involved in two Horizon 2020 Innovative Training Networks which now contribute to 3 FFG-funded projects.

## Scientific publications in the field of quantum research: Austria in 2nd place among the EU-27

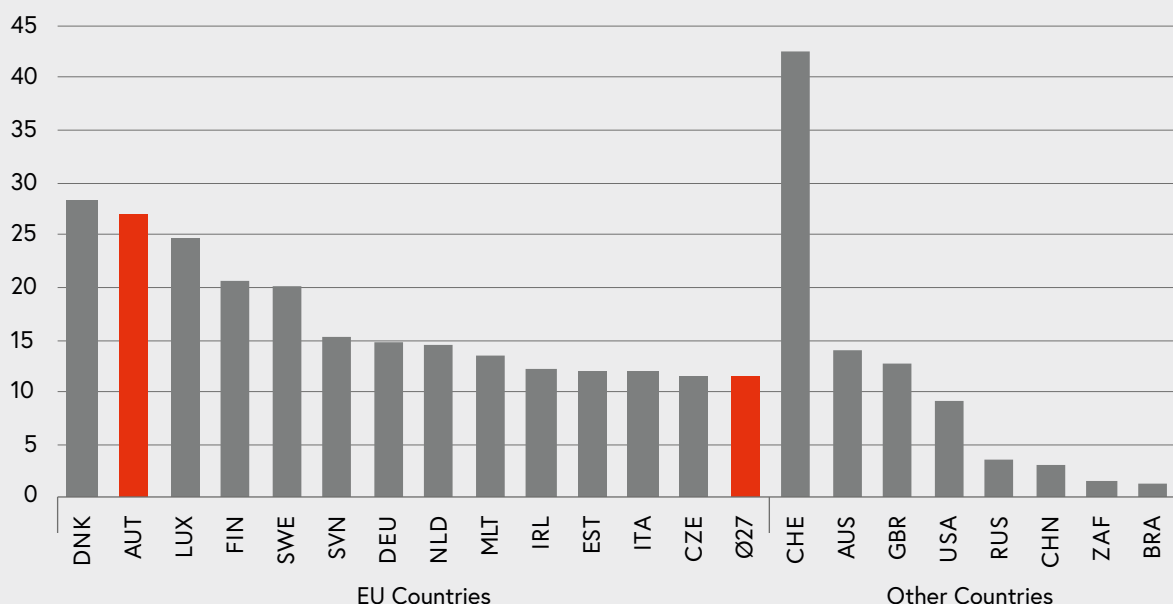


"With around 27 publications per million inhabitants, Austria achieved second place in 2022, making it one of the leading top 3 nations in the EU-27 country comparison for the third year in a row."

Figure 4 shows the result of the bibliometric analysis for the year 2022, which was carried out using the Scopus publication database. Publications in the field of quantum research that were published as scientific articles, reviews, books, book chapters, notes, short surveys or letters were included. In relation to the EU-27 average, Austria was once again able to widen the gap (gap to EU average 2021: 14.5; gap to EU average 2022: 15.5)."

As Quantum Austria research projects are still ongoing and publications will only be published in the final phase, further publications can be expected after the end of the funding initiative.

Figure 4: Number of scientific publications in the field of quantum research per million inhabitants for 2022 (limited representation of EU countries above the EU average value).



## Budget breakdown

### list of approved funding amounts

Overview of funding and projects approved in the Quantum Austria initiative by late July 2024:

Number of projects:	
FFG:	26 projects (with 67 participations)
FWF:	30 projects
<b>Quantum Austria total:</b>	<b>56 projects</b>

The detailed operational budget is shown in the tables in the previous section (Calls and approvals). At its meetings in 2023 and 2024, the Steering Committee agreed changes to the indicative budgets of the two funding agencies which are already considered in this report. Since September 2022, a total of EUR 26,500,998 in op-

Overall situation on 31/07/2024

	Available funding (€ million)	Approved funding	Approval rate
FFG	80.83	74.65	92.35%
FWF	23.03	22.64	98.31%
Qu-AT total	103.86	97.29	93.67%

erational funds have been paid to the funding recipients (first instalments for 21 projects, and 11 second instalments) by the reporting date (31/07/2024). In accordance with draw down requests and project instalment plans, the FWF paid out EUR 13,534,065 in funding by the reporting date.

# Ongoing projects in context

Most of the above projects have now been running for over a year. A general list of all FFG projects (publication approved by the respective funding recipients) is available at [www.ffg.at/quantum-austria/projekte](http://www.ffg.at/quantum-austria/projekte). The FWF's [Research Radar](#) offers a similar overview.

Some of the Quantum Austria projects are presented below.

**Multi-Site Computer Austria – MUSICA**  
Project management: Ernst Haunschmid (TU Vienna)  
Funding instrument: R&D Infrastructure Funding



Numerical simulations have joined theory and experiments as an integral part of modern science. In many cases, they allow theoretical predictions to be compared with experimental results for the first time. Due to the huge complexity of many of the systems investigated and modelled today, these simulations need to be run on high-performance computers. In addition to these simulations, such high-performance computers are increasingly being used in artificial intelligence applications. Machine learning in particular is used in almost all areas of research, and demand for the associated resources and services is rising sharply. Facilitating access for researchers from a wide range of disciplines is crucial. This requires not only investment in computing resources, but also expertise in establishing and expanding organisation of the support and services offered. MUSICA will provide scientific research with state-of-the-art research infrastructure:

- Supplementing and expanding existing research infrastructure in the field of *high-performance computing* (Vienna Scientific Cluster – VSC);
- Connecting and integrating a quantum computer into an HPC system;
- Installation in three federated locations increases availability and resilience.
- Implementing an *on-premises* cloud infrastructure to supplement the conventional use of HPC systems facilitates innovative and interactive use.

In recent years, the VSC has successfully developed into an Austrian HPC infrastructure including expertise in the fields of procurement, operation, user support, and training. However, when comparing the available computing power by country size against other equally developed countries (benchmarking), it quickly becomes clear that Austria is lagging significantly. MUSICA will be the major step forward. In future, the system's networked structure will serve to facilitate the integration of data-intensive user groups, such as high-performance genome analysis or cryogenic electron microscopy, for example.

After tendering, the contract was awarded to the companies edv-design (computing) and MEGWARE (storage) in December 2023. In the third quarter of 2024, two of the three subsystems were delivered and installed at the Vienna site. Acceptance is planned for 2024, and the subsystems will be available to researchers in test operations at the beginning of the new year. After completion of the computer rooms in Linz and Innsbruck during 2025, the subsystems will be installed and put into operation at their respective locations. The necessary network infrastructure will be planned and implemented together with AConet. The software and operating concept for the distributed system was developed in an international cooperation with StackHPC (UK).

MUSICA's total computing power will be available from the third quarter of 2025. The substantial number of state-of-the-art graphic cards makes MUSICA particularly attractive for AI workloads, as shown by inquiries from research and industry.

The RRF funds allow an internationally competitive HPC infrastructure to be established for the benefit of Austrian science and industry. Without RRF funding, this goal would have been completely unachievable, making it unreasonable to even define the corresponding milestones. To provide researchers with the resources and opportunities available via MUSICA on a permanent basis, appropriate investments in research infrastructures and associated support organisations will be necessary under the "umbrella" of Austrian Scientific Computing (ASC).

## High-Performance integrated Quantum Computing – HPQC

Project management: Thomas Monz (University of Innsbruck)

Funding instrument: Flagship Project



Over the past two decades, Austria has successfully developed the first quantum computers for international use. In 2020, the team in Innsbruck presented the first quantum computer, built in an industry standard 19-inch rack. Although this development represented huge progress in physics and engineering, it has been nearly impossible for non-physicists to use the computer for calculations. Against this background, the HPQC consortium has set itself the goal of integrating a quantum computer into a high-performance data centre. The data centre is familiar with user administration and can provide access for a wide group of users including research and teaching staff. Integration into existing structures simplifies standardised access and allows the development of "quantum libraries" which directly use existing quantum computers without requiring users to have a detailed knowledge of quantum mechanics. Interdisciplinary research and development will use this infrastructure to advance technological progress.

As part of this project, we will integrate a quantum computer (QC) directly into an Austrian high-performance computing (HPC) environment, thus creating the first fully integrated, hybrid QC/HPC infrastructure in Europe. Building on the existing QC and HPC infrastructure in Innsbruck, the consortium will improve the QC hardware to enable calculations beyond the capabilities of traditional computers. The new interfaces between HPC and QC will facilitate and accelerate the development of quantum computers and serve as a building block for the development of high-level languages for the hybrid quantum/HPC future. Consequently, this project serves as a bridge between quantum research and computer science and subsequently strengthens the Austrian and European quantum ecosystem.

With partners from Innsbruck, Linz, Vienna, and IBM in Switzerland, the consortium has successfully integrated a quantum computer into LEO, the high-performance computing infrastructure at the University of Innsbruck. Consortium partners such as Math.Tec have already used the system to solve application-oriented optimisation problems in the logistics sector, while TU Wien partners have used the system to examine classic machine learning. In parallel with this software development, the team in Innsbruck has created a novel system based on trapped barium ions and undertaken initial measurements. The intention is to store quantum information in the ground state of barium, which is expected to reduce error rates by a factor of at least ten.

Particular attention was paid to implementing industry-related use cases which guide further development steps. Working together with partners including BASF and Böhringer-Ingelheim in Germany, the team in Innsbruck was able to demonstrate the first chemical calculations that are sufficiently accurate for industrial application. The complexity of the molecular structures achieved with BASF surpasses all previous demonstrations at international level. In addition, machine learning was successfully applied to quantum data with partners in Munich to determine phase transitions in systems without further human interaction.

## Quantum Communication Chip-Scale Co-Integration for Zero-Trust Datacenter Security – QITTY

Project management: Dinka Milovančev (Austrian Institute of Technology GmbH)  
Funding instrument: Individual Project of Industrial Research



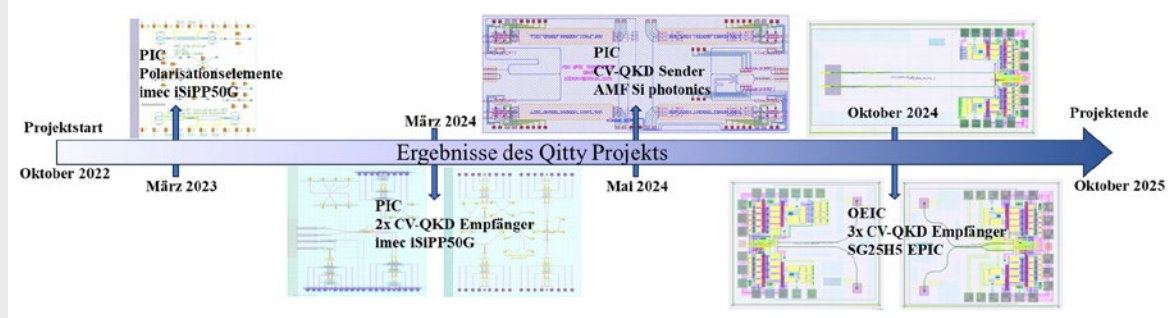
The increasing proliferation of cloud services brings with it an increased security threat that requires a zero-trust model for use in data centres. Security is best ensured by quantum cryptography primitives, which must be highly integrated into the data centre's hardware. The CV-QKD approach was chosen because integration into and combination with existing fibre infrastructure appears to be possible.

The goal of the QITTY project is to develop QRNG/CV-QKD chips:

- CV-QKD transceivers in the form of photonic integrated circuits (PIC) on an SOI platform which encompass polarisation control, optical transmitters, and receivers wired to electronic chips;
- Fully monolithically integrated CV-QKD receiver and QRNG engine (photonics and electronics on the same wafer);
- Experimental evaluation for data centre applications striving for secure key rates of >10 Mb/s and QRNG rates of 10 Gb/s.

We have developed 7 different chips to date: PICs and optoelectronic integrated circuits (OEICs) on 3 different integration platforms, as shown below. The chips are scheduled for measuring in the last year of the project. At the same time, we are investigating the polarisation-independent CV-QKD system with our die-level precursor receivers as well as multifunctional transmitter operation, enabling both CV-QKD and DV-QKD transmission. The greatest challenge is long and unpredictable delay times, as well as the technological maturity and reliability of available design platforms.

Figure 5: QITTY project results



The main milestones achieved so far are the successful first tests and the setup of the CV-QKD testbed, as well as delivery of the first PIC containing integrated polarisation structures on silicon. The next milestones depend on the delivery times of the designed chips. It would not be possible to cover the high cost of design and production without FFG funding under the Quantum Austria initiative.

## Automated Solution Path for Quantum Computing – ASQ

Project management: Wolfgang Lechner (ParityQC GmbH)

Funding instrument: Cooperative R&D Project



Combinatorial optimisation problems arise in various forms in almost all areas of science and industry, and in larger instances pose a challenge to conventional methods. With the help of various, often heuristic quantum algorithms, there is sufficient reason to believe that some of these problems can be solved faster or better than is currently possible. However, there are many varieties of algorithms and methods, as well as hardware, for solving optimisation problems.

Therefore, the main goal of ASQ is to implement the entire solution path for general optimisation problems using quantum algorithms and hardware and to find the best options in the path. The approach involves cataloguing both the algorithmic building blocks and the quantum hardware, and comparing key parameters such as execution speed. Based on selected metrics, a "digital assistant" will automatically propose the optimal solution path for each given problem instance.

It is to be expected that different solution paths are more or less suitable for certain classes of problem. Therefore, the project will also provide a library of pre-implemented optimisation problems and enable the formulation of new problems. Appropriate criteria will be identified for problem classification. These problems can be used to carry out extensive benchmarking of the algorithmic building blocks and the hardware.

During the project, ParityQC, in cooperation with the University of Innsbruck, has already finished cataloguing a variety of quantum hardware platforms and has published the results. Furthermore, algorithmic building blocks such as different encodings, variational quantum algorithms with components such as constraint preserving mixer terms, and transformations such as different variants of parity compilation or QUBO transformations have been identified and included in the software package. These components have been benchmarked based on a variety of concrete optimisation problems taken from the problem library. Tools for implementing new problems and problem classes, such as a (hyper) graph library and cost function blocks, have been integrated into the software package. Based on the metrics identified for different aspects of the solution path and the problem input, an optimal solution path can be determined by directly trying out the options or by using machine learning methods, with the latter approach currently still in the development and testing phase.

## All-optical 3D Quantum Sensor for Magnetic Fields

Project management: Roland Lammegger (TU Graz)

Funding programme: 1,000 Ideas Programme



The research project aims to realize a magnetic field measuring instrument which puts atoms into a quantum mechanical superposition state. This state is composed simultaneously of two energy states that atoms can usually occupy. 'Non-classical energy states' are a phenomenon of the quantum nature of matter, which do not occur in this form in everyday life.

These special states allow the energy levels of specially prepared atoms to be measured with a resolution 1,000,000 times greater than that of conventional methods. In the present case, for example, magnetic fields 100,000 times smaller than the Earth's magnetic field are sufficient. The experimental setup works as a highly sensitive magnetometer, which allows magnetic fields to be measured with highest absolute accuracy.

Another special feature of this research project is that, besides the mere value of the magnetic field strength, also its direction is extracted from the observed signals of the quantum mechanical superposition state.

Furthermore, it is investigated whether this method can be applied for the detection of land mines, the measurement of the earth's magnetic field or the detection of mineral resources.

## Quantum Optics with Electron-Photon Pairs

Project management: Philipp Haslinger (TU Wien)

Funding programme: Principal Investigator Projects



Electron microscopy is a highly developed technology that employs the wave properties of electrons to resolve structures at an atomic level. In this project we want to utilize Cherenkov radiation - which is generated by uniformly moving charged particles (electrons) with velocities exceeding the speed of light in a nearby dielectric medium - to create correlated electron-photon pairs, within a transmission electron microscope. This would enable a powerful new platform to study interesting quantum phenomena with far reaching applications, due to their different physical properties: the massive electron with picometer de Broglie wavelength, enabling atomic resolution, and the Cherenkov photon with micrometer wavelength, which is easy to guide, manipulate and detect in a phase coherent manner. We envision bridging the very successful fields of quantum optics and electron microscopy.

## Quantum Science Austria

Project management: Gregor Weihs (University of Innsbruck)

Funding programme: Clusters of Excellence



The Second Quantum Revolution, the breathtaking development of modern quantum science, would not have been conceivable without the groundbreaking and Nobel-prize-winning contributions from Austria, such as quantum teleportation or the proposal of a trapped-ion quantum computer. These contributions are the basis on which quantum technologies are now being developed that surpass classical technologies in many areas. It is expected that they will revolutionize precision measurements, telecommunications, and above all the computation and simulation of complex many-body quantum systems, which are at the heart of important technological problems ranging from biomolecules to quantum materials.

While scientists are learning more and more about the use of quantum physics, other fundamental phenomena, especially in cosmology, still lack a conclusive explanation. Even though the physics of gravity and that of quanta are well understood in their own right, there are no descriptions of phenomena where both areas have strong influences. For example, no one currently knows what is really going on inside a black hole. To solve these essential questions a much better fundamental understanding of complex quantum processes is needed.

The central goal of the Cluster of Excellence 'Quantum Science Austria', is to expand the frontiers of knowledge in quantum science and thus to be a driver for future innovations. The focus is on fundamental questions about the quantum nature of space, time and gravity, new paradigms in quantum information science and the physics of quantum many-body systems.

The scientists in Innsbruck, Vienna, Linz and Klosterneuburg ask innovative questions that can only be solved by combining the unique know-how available in Austria. Using world-leading theoretical methods and precisely controlled model systems based on trapped ions, ultracold atoms, long-range interacting systems, superconducting quantum circuits, and nanoscopic solid-state systems, they aim to unravel the most difficult mysteries of the quantum world. With their advanced solutions, they will prepare the ground for the next generation of quantum technologies. An intensive training program will educate the quantum scientists of the future, who will make these technologies ready for practical application.

# Outlook

The FFG will have received the last of the initiative's funding commitments by the end of 2024, while the FWF received the last commitments already at the end of July. This means that Quantum Austria is now in its most active research phase, so that the focus of the FFG and FWF will shift to monitoring and other accompanying measures. One such measure is the networking meeting originally planned by the FFG and FWF for September 2024 which will now be held in Vienna in March 2025, during the Inter-national Year of Quantum Science and Technology. It is intended to hold this research community event in the run-up to a "Workshop on Quantum Satellite Networks" jointly planned by the ESA, FFG and AIT for March 2025, leveraging synergies beyond Quantum Austria. A further (final) Quantum Austria initiative networking event is scheduled to take place in Innsbruck in the autumn. Beyond Quantum Austria, the two agencies, the BMBWF and the Austrian quantum community, are planning<sup>1</sup> many more activities and events for the United Nations' upcoming International Year of Quantum Science and Technology.

At the beginning of 2025, a majority of the second interim reports for FFG projects are expected, with the first final reports of the FWF projects arriving in the second half of the year. Most projects will finally achieve their goals between late 2025 and early 2026, which will then be presented in the final reports, by March 2026 at the latest. An overview of the successes (CID fulfilment) will be presented in a joint final report by the FWF and FFG later in 2026.

Since the last Quantum Austria calls under the umbrella of the NextGenerationEU Austrian RRP will be launched in 2024, it is worth looking not only at the outcome, but also at the supporting and upcoming activities, both at European and Austrian level.

One example of national activities to further promote industrialisation and development to market maturity is the new *Qu2M – Quantum to Market* initiative to be managed jointly by aws and the FFG. This initiative is designed to support the industrial implementation and economic exploitation of quantum technologies in Austria. The dissemination and commercialisation of quantum technologies will be facilitated, implemented, and

scaled by promoting pilot plants, cooperative projects, R&D infrastructures and quantum technology products and processes. As a supplement to the Quantum Austria initiative's focus on quantum computing/simulation and quantum communication/cryptography, the research activities will also pay particular attention to quantum sensor technology/metrology. At the FFG, this will be accompanied by community management to optimise support for stakeholder networking in this rapidly growing technology area. These activities will be funded by aws and the FFG, with each receiving EUR 4 million from the Austrian Future Fund (FZÖ)<sup>2</sup>.

These joint funding activities are supplemented by ongoing opportunities for submission to the standard programmes offered by the FFG and FWF. Those worth noting here include the FFG's General and Structural Programmes, especially via Spin-off Fellowships and other programmes for start-ups. Submissions at European level are also managed by the FFG's European and International Programmes (EIP) on an ongoing basis. The FWF, in turn, makes available open-topic funding programmes for all career stages, together with accompanying communication measures.

Furthermore, Austria is already involved in numerous European activities. One significant activity is the Quantum Internet Alliance. Launched in 2022, it aims to establish a European ecosystem for a quantum internet within 7 years. Austria is also continuously involved in QuantERA II, in which the FFG and FWF are network partners, as well as in EuroQCI<sup>3</sup>. The successor to QuantERA will start in 2025; it is expected that the submissions made in autumn 2024 will have been evaluated by early 2025. For EuroQCI, one Call is currently open under the *Connecting Europe Facility (CEF)* programme<sup>4</sup> (deadline: 13/02/2025). National funds from the FZÖ are available for co-financing (the corresponding Call is currently being drawn up at national level).

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1 <https://www.quantumscience.at/quantum2025/events>

2 <https://fti-monitor.forwit.at/docs/pdf/R000001.pdf>

3 <https://digital-strategy.ec.europa.eu/en/policies/european-quantum-communication-infrastructure-euroqci>

4 <https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/CEF-DIG-2024-EUROQCI-WORKS>

## Research infrastructures in the European Research Area: Quantum Austria in the Austrian Research Infrastructure Action Plan 2030



One intention of Quantum Austria is to promote excellent research infrastructures in the field of quantum research and technologies, because they are a key aspect of the European Research Area (ERA). They are an essential framework for the RTI system as well as an important prerequisite for other initiatives, making further development of research infrastructures (including e-infrastructures) a central and ongoing task for both national and European research policy. As a result, Austria participates in important processes and projects in this field at EU level (especially the ESFRI roadmap process), and is also setting the course at national level, through the Austrian Federal Government's RTI Strategy 2030.

The Austrian Research Infrastructure Action Plan 2030, developed as part of the RTI Strategy 2030, is the central instrument for shaping the expansion of research infrastructure and participation in European and international (large-scale) research infrastructure, offering a development perspective up to 2030. Quantum Austria is an essential part of the development approach to research infrastructure. It will support long-term basic research and technology development in the field of quantum and high-performance computing. The action plan follows the principle of coordinated procurement and shared use of research infrastructure.

The Research Infrastructure Action Plan 2030 is part of the Austrian Action Plan for the European Research Area (ERA-NAP) 2022–2025. Based on the Pact for Research and Innovation in Europe, and the ERA Policy Agenda 2022–2025 derived from it, the Research Infrastructure Action Plan 2030 – specifically Quantum Austria – contributes to establishing the European Research Area as a "European research area in which researchers, scientific knowledge and technology circulate freely" in accordance with Article 179 TFEU.

# Summary of the conducted audits

Following the audit of the FFG and FWF's internal control system conducted by the BMBWF's internal auditor from mid to late 2022 (reporting date: 19 December 2022), three recommendations were made to the FWF:

- Recommendation ID E.BMBWF.QA.01, FWF Commercial Vice President: to evaluate whether general wording such as "sensitive business cases" (*heikle Geschäftsfälle*) is sufficient for the IQS handbook. If necessary, this could be more precisely specified.
- Recommendation ID E.BMBWF.QA.02, Commercial Vice President: to assess the operational risks according to a risk matrix (analogous to the strategic risks).
- Recommendation ID E.BMBWF.QA.03, Compliance Manager: to evaluate whether the FWF could also use interactive e-learning training tools incl. examination questions.

While restructuring risk management at the FWF, the strategic and operational risks will be standardised and fully documented. A prioritisation list for risk documentation of internal processes is nearing completion. The IQS handbook is currently being revised.

Compliance training was mandatory for all employees in 2023. Both the available documents and case studies were discussed, and there was room for discussions and questions. In addition to face-to-face and hybrid training, in future interactive e-learning training tools will also be used.

Furthermore, on 13 September 2023, the Federal Ministry of Finance organised compliance training for all processing agencies involved in the Recovery & Resilience Facility; the FFG and FWF also participated. Key topics covered during the training were preventing and combating fraud, conflicts of interest, multiple funding, and corruption.

In addition, the Council of Ministers stipulates that the FFG and FWF must report to the Federal Ministry of Finance on the achievement of the milestones and goals. The FFG and FWF meet this reporting obligation through their existing contractual obligation to report to the BMBWF (contracting and supervisory authority), which in turn reports to the Ministry of Finance.

Information about Quantum Austria funding is also stored in the transparency database where it is presented accordingly and checked for any duplicate funding.



FUNDING INITIATIVE  
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