ETH Zürich Foundation

Uplift

The impact of giving

№6

It's time to make the most of the opportunities
Quantum physicist Renato Renner

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Why I support talented ETH students
Bigna Salzmann

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Support

Quantum research

ETH Foundation

“With your support, ETH can perform ground-breaking work in an extremely exciting area of research. Quantum technology opens up new horizons in all scientific disciplines. Join the quantum revolution!”

Joël Mesot,
President of ETH Zurich

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The future draws nearer

Yiwen Chu researches new ways of connecting quantum technologies, with the aim of creating a quantum telecommunications network for the exchange and storage of quantum information.

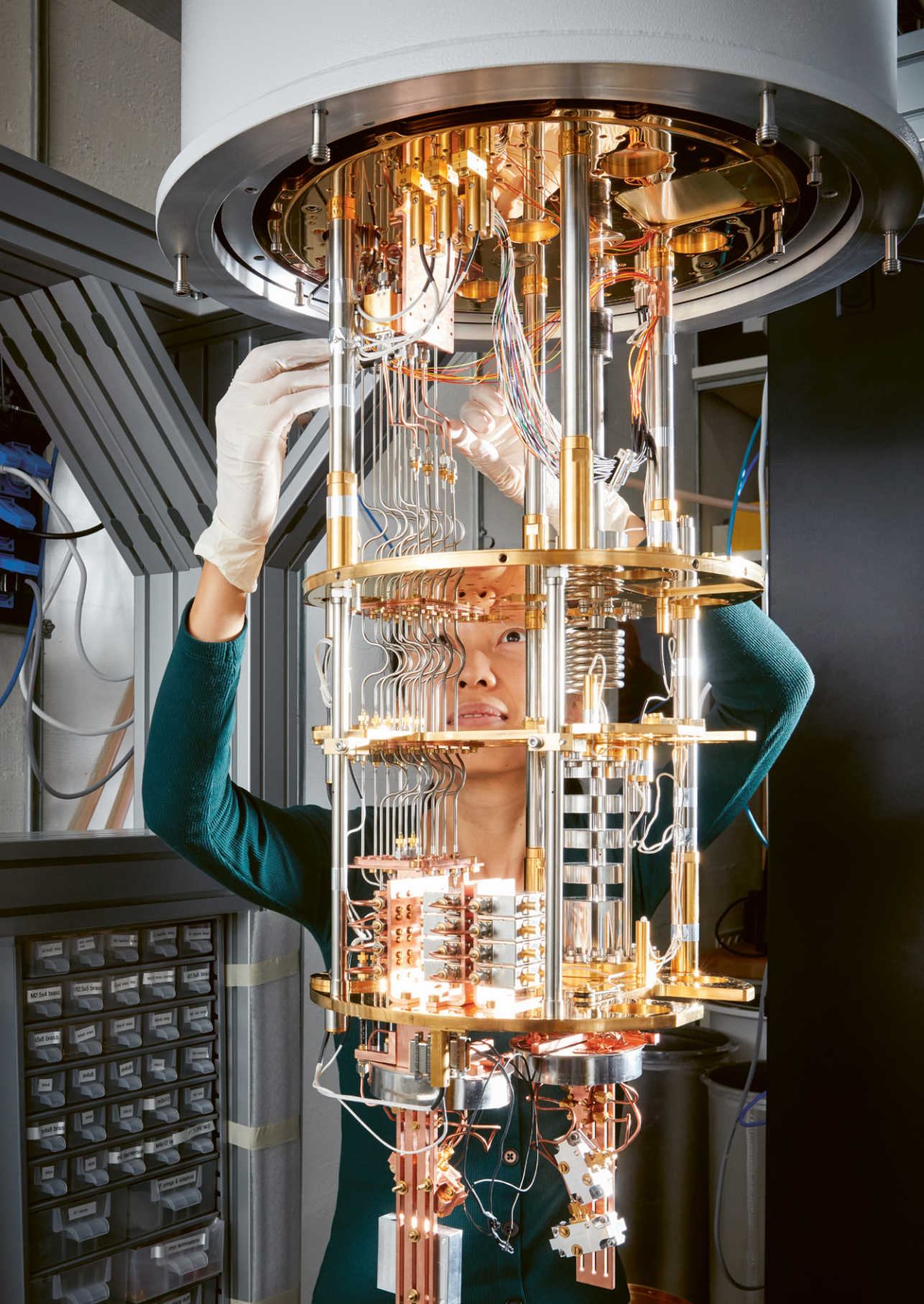
Planting tomatoes on her balcony, playing the piano, climbing – Yiwen Chu's leisure activities are no different to those of many other 30-somethings. But the similarities stop there. With her research group for Hybrid Quantum Systems, the young assistant professor aims to build new quantum information systems and help to better understand how our world works at its core.

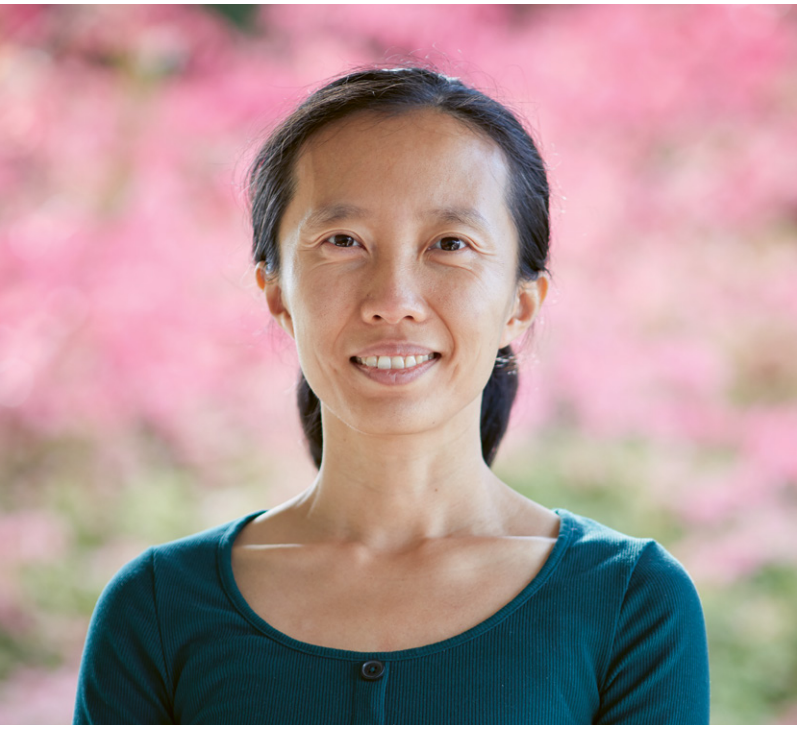
Charting new territory

Chu has been at ETH Zurich since the beginning of 2019, having previously been a researcher at Yale. The move to ETH was an easy one: "I already knew a lot of people from earlier research collaborations, so I had no problem fitting in," she explains. She enjoys the freedom and support she receives here for her research: "The current state of development of quantum information processing systems is comparable with the beginnings of the computer age. We are investigating which technologies and parts are necessary in order to facilitate information exchange and store data." Chu's research group aims to develop new methods and devices to connect various types of quantum objects and transmit quantum information. The group is also conducting basic research into where the boundaries between the quantum world and the classical world lie. In September, the young researcher received additional support for her research project in the form of a Starting Grant from the European Research Council (ERC). Chu's aim is to build a kind of quantum telecommunications network. "This grant is a great confirmation that our work is moving in a promising direction, and motivates us even more," she says.

Applications in just a few years' time

Questions abound – but she has the enthusiasm to match. Chu knew at an early age that she wanted to be a physicist, but not in which field. "When I first learned about quantum physics, it was mind-blowing," she says. The researcher is convinced that major developments will be possible in the coming years, because not only will we understand the processes of quantum mechanics, we will also be able to really use them, for example in cryptography or to simulate chemical reactions: "I'm fascinated by how we are constantly pushing the boundaries of what is possible. I also love every aspect of my work, from experiments in the lab, through computer calculations to the interactions with colleagues and students." →





“Just as in the early days of the conventional computer, we are currently finding out which technologies work.”
Yiwen Chu

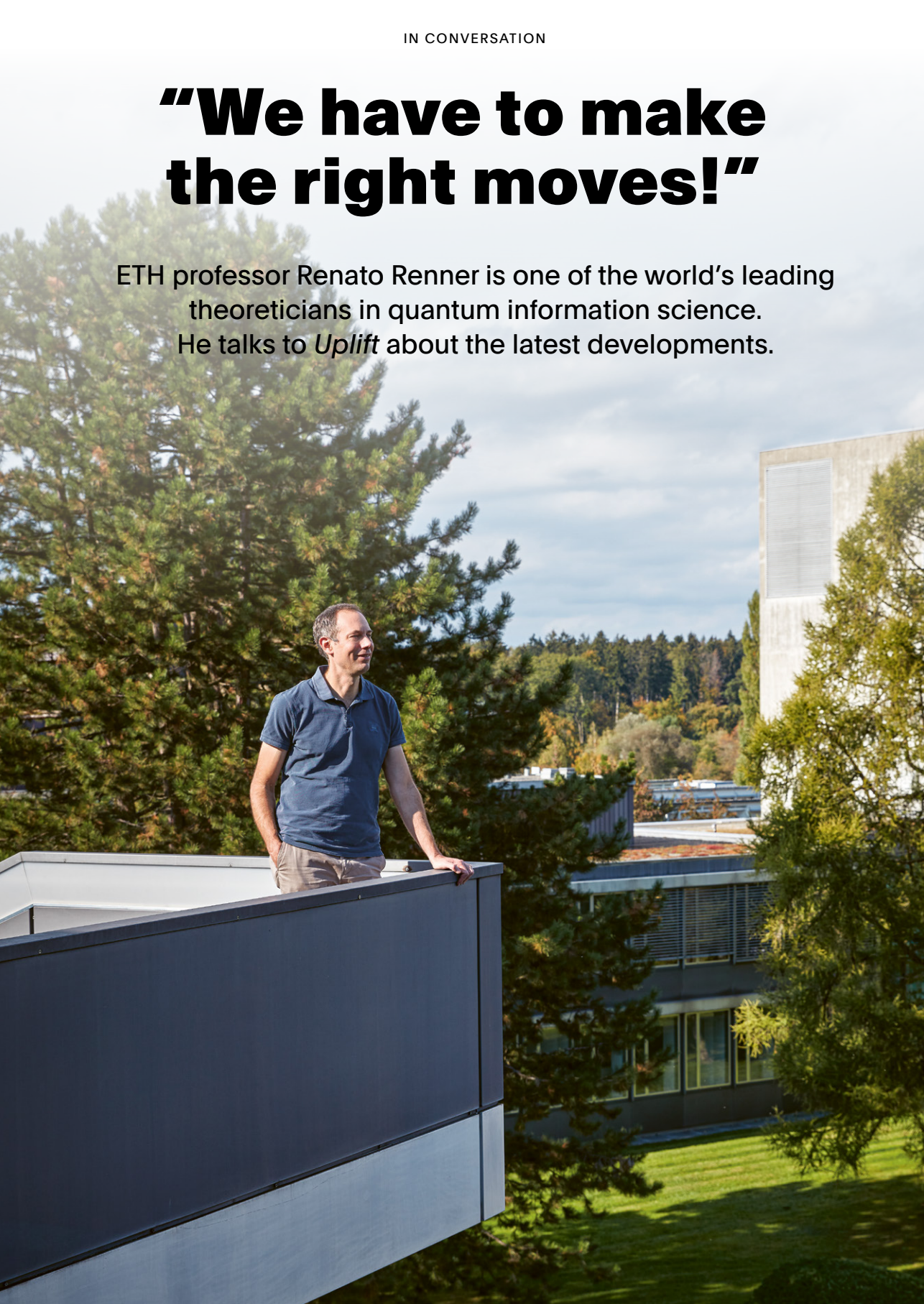
→ For Chu, the opportunities for exchange are essential. She is part of the National Centre of Competence in Research QSIT (Quantum Science and Technology), in which 31 research groups from different Swiss institutions regularly exchange ideas about projects and developments. Chu is looking forward to the new physics building HPQ (see page 15), which she helped to plan: “It will be much easier to work together with other research groups on developing exciting approaches.” She also receives input at home from her partner, whom she met during her postdoc work at Yale and who also works in the field of quantum information, at the Paul Scherrer Institute (PSI).

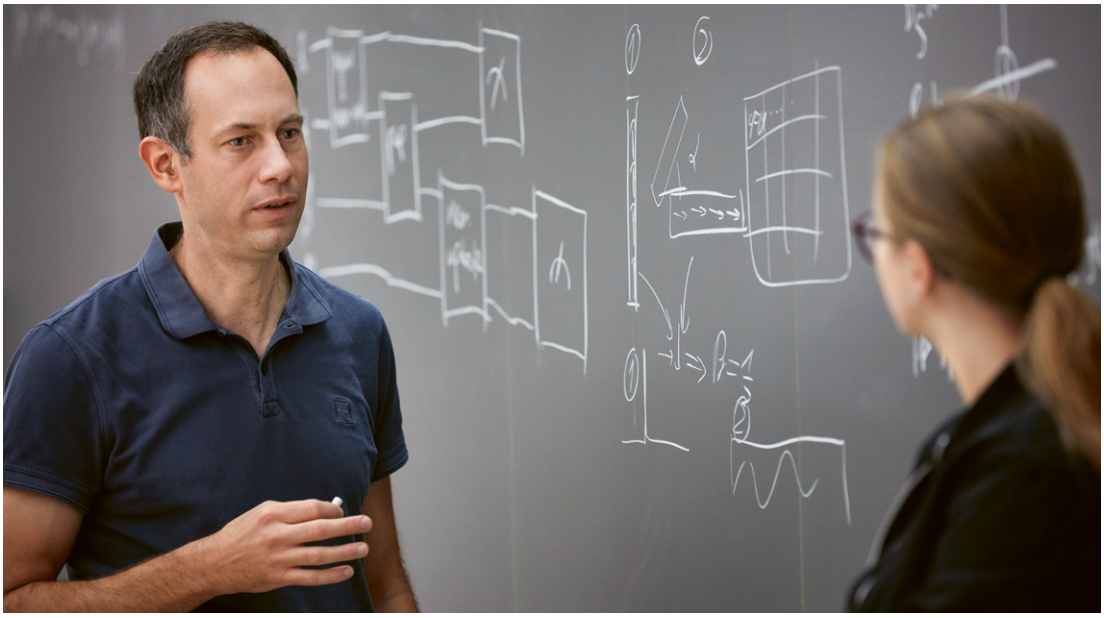
Breakthroughs thanks to perseverance
Chu’s most important tip for young scientists is to believe in yourself. “The more successful your research is, the more brilliant the people who surround you. Resilience and perseverance will get you so much further than self-doubt,” she says. This attitude has proved effective for this young researcher – her research group is growing and she is confident that the next generation of hybrid devices for processing quantum information will become reality in a few years. And she will definitely be able to benefit from her perseverance during the coming winter, when she plans on learning to ski.

Accelerating progress in quantum science at www.ethz-foundation.ch/en/quantum

“We have to make the right moves!”

ETH professor Renato Renner is one of the world’s leading theoreticians in quantum information science. He talks to *Uplift* about the latest developments.





You studied at ETH in the 1990s – how did quantum information science stand back then?

RENATO RENNER – Just as at most universities, the field did not yet exist at ETH. Nevertheless, Klaus Hepp, now emeritus professor for theoretical physics, with his foward-thinking approach, offered a seminar on the subject. I asked what I should do if I wanted to look into the field more closely. Hepp advised me to contact the computer science professor Ueli Maurer, who, he said, was very open to new subjects. He was indeed – open enough to take me on as a doctoral student. He said he knew little about quantum information, but was happy to learn. *(Laughs.)*

You are a father of four; how do you explain to your children what you do for a living?

When it comes to the two younger ones, I simply say that I do research – theoretical research. This means going places in your thoughts where no one's ever been. Then I explain that if you keep on zooming in on Google Maps, something fascinating happens – new laws suddenly apply. Laws that are so different to everything we know that you almost believe we're in a different world. Even the concept that everything can only be in one place at a time doesn't work in this "new" world.

Which leads us to the question: why does the world as we know it from our everyday life not obey these different laws?

There are two outlooks on this: one assumption is that the laws of quantum physics no longer apply to large objects such as a coffee cup, where many particles come together. The alternative hypothesis is that even a coffee cup is subject to these laws. As we do not have the appropriate measuring instruments, we cannot perform the experiments to find out. What we can perform, however, are thought experiments: what would be the result if we did have these devices? Like most physicists of my generation, I believe that the laws of quantum physics apply on a large scale with all the consequences this implies, such as that I could theoretically be in two places at once. In principle, my entire research is based on turning this question of "belief" into one that can be resolved by science. For me, the scope within which quantum mechanics can be applied is the central issue.

"The benefit of quantum information today? Modest. The potential? Huge!"

Renato Renner

And what are the specific social benefits of quantum science?
If we're honest, we have to say that the current applications are modest. The potential, however, is huge! But we do not yet know what the "killer application" will be. The situation is comparable with that 80 years ago, when the first primitive computers were developed. If we had asked about their benefits back then, no one would have thought that one day we would all have a mobile phone in our pockets and use them to do all manner of things. It's important to understand that at the moment, not only the hardware but also the software is lacking. This means that we not only need quantum computers, but also an army of quantum software engineers. We have now started training these people at ETH.

Huge sums of money are being invested in this research worldwide. How is ETH positioned in this race?
Ten years ago, ETH was one of the few universities that had a broad range of expertise in quantum science. We continue to play a leading role, but the field of competition has become huge, from Canada to China. We are currently at a critical point, and have to make the right moves if we want to maintain our position! We can only achieve this in collaboration with industrial partners. Students also benefit from these partnerships; for example, an internship at IBM Research gives them the opportunity to program on a quantum computer, which ETH alone would be unable to offer.

Why does quantum science deserve to attract attention within society in the form of philanthropy?
Support in this area promotes basic research that has the potential to enable progress in a wide range of applications. The development of new drugs, for example, is hugely data-intensive, and supercomputers could be a game-changer in this regard. Anyone who supports quantum science is thus helping to solve problems in many socially relevant areas simultaneously by making these innovative and potentially hugely powerful tools available.

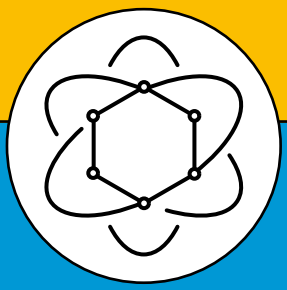
Accelerate progress in quantum science at www.ethz-foundation.ch/en/quantum

Quantum information theory at ETH Zurich

Renato Renner's group focuses on the question of how the processing and transmission of information relates to physical laws. The group studies the opportunities created by quantum physics for information processing, and how these may be exploited. The researchers also hope to gain a deeper understanding of physical relationships through information theory.

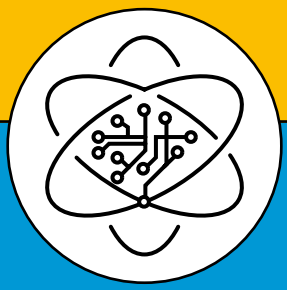
For quantum leaps in science and technology

Quantum research has the potential to change our daily lives in the following areas:



Chemistry

Quantum mechanics form an important basis for computer models that simulate chemical reactions and could be hugely beneficial in fields such as drug research.



Electronics

As electronic components get smaller and smaller, they no longer behave according to the laws of classical physics, but follow the rules of quantum mechanics.

Cryptography

Quantum cryptography enables data to be transmitted in such a way that it cannot be read by anyone else as it travels.

The principles of quantum mechanics were developed at the beginning of the 20th century. Since the turn of the millennium, science has had the technical capability to intensively research its enormous application potential. ETH Zurich invested in this field at an early stage and today occupies a leading position

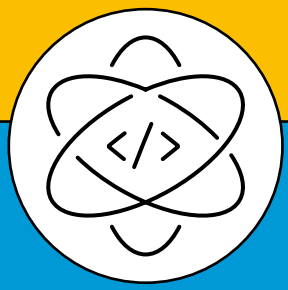
Your support enables

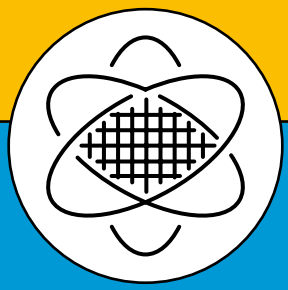
- The development of a technological basis for the manufacture of quantum computers and the corresponding software and components.
- A new doctorate programme in quantum science and technology.
- Two new professorships, to ensure that ETH is even better positioned for the quantum revolution.

Support us now: www.ethz-foundation.ch/en/quantum

Video insight

The “Quantum Center, ETH Zurich” builds on the National Centre of Competence in Research (NCCR) Quantum Science and Technology (QSIT):





Computer science

A quantum computer could, for example, search extremely large databases highly efficiently, thus revolutionising road traffic planning or climate research.

Measuring technology

Atomic clocks are extremely precise timepieces. The next development step will be a nuclear clock, which would make GPS much more accurate, for example.

Materials research

Today, materials can be investigated and altered down to the atomic level, thanks among other things to the scanning tunnelling microscope, which is based on a quantum mechanical phenomenon.

Illustration: ETH Zurich

worldwide, both in education and research and development. In order to reinforce this position and take advantage of it in as many areas as possible, ETH plans to establish the new “Quantum Center, ETH Zurich” together with the Paul Scherrer Institute (PSI).

Breaking new ground

ETH graduate and donor Bigna Salzmann's love of nature has been a recurring theme throughout her life. She believes innovative ideas are needed when it comes to protecting our natural environment, and ETH has a role to play here, too.

When you think back to your ETH studies, you think of forests. Why is that?
BIGNA SALZMANN – During my Bachelor's degree in environmental sciences I chose to specialise in "Forest and Landscape", and spent a great deal of time outdoors. I did my Master's thesis at the Swiss Federal Institute for Forest, Snow and Landscape Research WSL, and in the Swiss National Park. The forest was a key element of my studies, but nature and the environment have interested me since childhood. As a young girl, I published a magazine for nature-lovers, which my father had to copy for me at his office.

Why do you support ETH Excellence Scholarships?
We can only master the challenges of the future if we give people with outstanding abilities the necessary freedom for innovative research. These talented students have the potential to create something new. I also believe it's essential to provide support for start-ups.

What is it that keeps you connected to ETH?
Mainly my professional network – Switzerland's environmental scene is not so huge. I often meet former fellow students in my everyday work. If I need a professional opinion, it's very helpful; I usually find I know someone with the relevant expertise who I can contact.

To what extent is your working life built around your ETH studies?
As a Senior Corporate Responsibility Manager at Swisscom, I advised the business customers division on the issue of sustainability. I was also responsible for the topic of climate protection, and investigated potential new forms of working as part of the "Work Smart" initiative. At Freitag, I now focus on what is known as the "circular economy", i.e. the question of how energy and material flows can be created and managed in a more resource-efficient manner. My studies gave me a good grounding in all these areas, but everything is of course a great deal more complex in reality than in theory. →

"We can only master the challenges of the future if we give people with outstanding abilities the necessary freedom for innovative research."
Bigna Salzmann

Bigna Salzmann likes to spend her free time in the fresh air – jogging, hiking or snowboarding.

→ You spend a lot of time dealing with future issues at work – how do you personally see the future, including as the mother of two children?
I have a very positive basic attitude, and generally believe that problems can be solved. Sometimes it's just a case of what you focus on: instead of saying that we shouldn't eat meat every day, we can take pleasure in the variety of vegetarian food. Or when we travel on foot or by bike, we can place less attention on the fact that we're going without a car, and more on the exercise we're getting. For me, I see the excellent academic education I was able to enjoy as an obligation to raise awareness of possible solutions in a positive way, both at home and at work.

Nurturing outstanding talent

Every year, the ETH Excellence Scholarships support talented students in the top 2 to 3 percent of their year group. This allows them to devote themselves entirely to their Master's programme and provides the freedom necessary for first-class research. The Excellence Scholarship & Opportunity Programme (ESOP) is made possible thanks to donors and partners.

Find out about ETH Excellence Scholarships at www.ethz-foundation.ch/en/esop

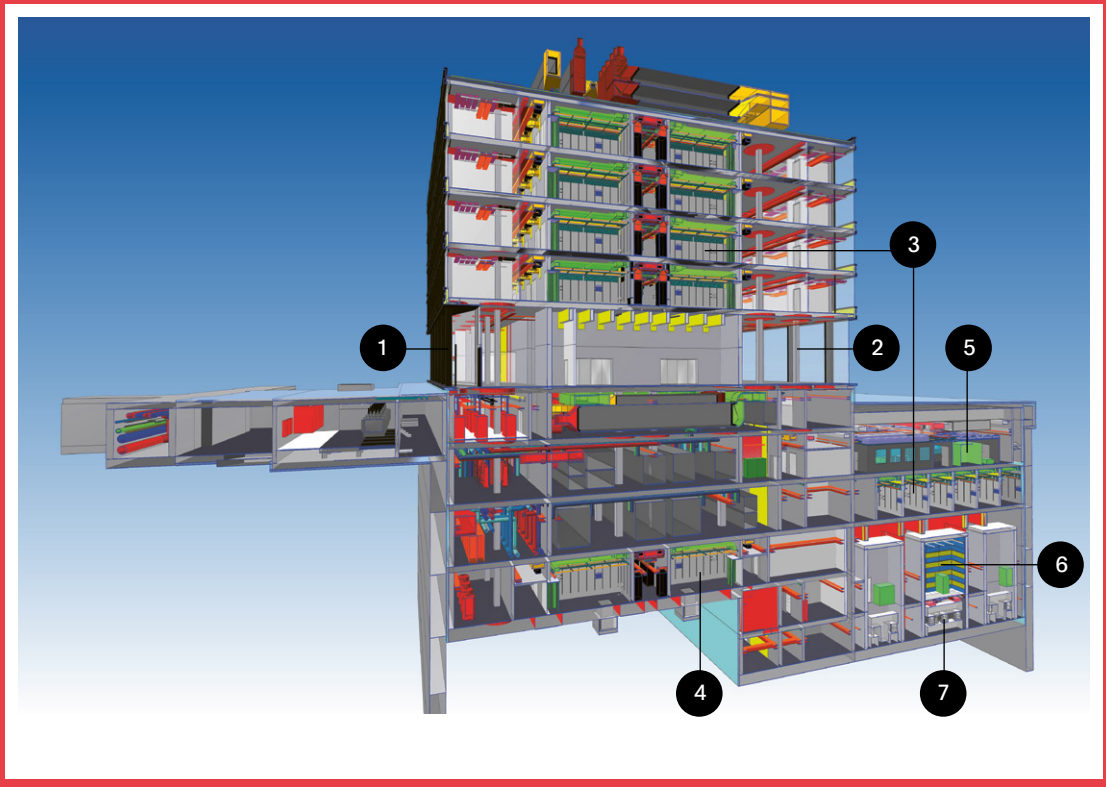
A new building for cutting-edge research

ETH Zurich is pursuing a complex construction project on the Hönggerberg campus with a highly ambitious goal: to research physical phenomena at the limits of technical feasibility.

Quantum phenomena manifest themselves on the smallest scales and in the shortest timeframes, and their use enables new and revolutionary technological applications, such as quantum computers, sensors and encryption devices. However, the research and development of new quantum components – or "qubits" – places extremely high demands on the isolation and control of all systems. In order to expand on this research at the limits of technical feasibility, a new physics building – known as HPQ – is being built on the Hönggerberg campus for 500 researchers and students. With its cutting-edge laboratories, the building will house three technology platforms (see plan). Daniela Rupp, Professor of Nanostructures and Ultrafast X-Ray Science and one of the future users of this high-end infrastructure: "You can count the number of complex research buildings at this level worldwide on one hand. With the HPQ building, we want to create the optimal basis for Switzerland as a research location to continue conducting cutting-edge physics research, and in particular to help drive forward the quantum revolution."

Extreme demands

HPQ, designed by Ilg Santer Architekten, will be located in the northern part of the campus, with construction scheduled to start in 2022 and last until 2028. The four above-ground laboratory and office floors, a public ground floor and parts of the complex technical infrastructure on the roof will be visible, while the extensive underground levels in the main and side buildings will house highly sensitive research equipment, laboratories and platforms. Perturbations from inside and outside the building must be avoided, as they can severely disrupt the sensitive experiments or even render them impossible. The demands placed on shielding from vibrations, electromagnetic compatibility, cooling performance and temperature stability are also correspondingly high.



Venturing into the unknown
Gianni Blatter, Professor of Theoretical Physics and representative of the HPQ project, emphasises: “This building will not only be a research facility for ground-breaking experiments, it is also an experiment in its own right.” Vibrations from the campus e.g. must be reduced by a factor of 100 for the most sensitive experiments. Blatter: “Many of the specifications for the building are defined as ‘best possible’, as even after years of the most in-depth analysis and calculation, we don’t know what we will ultimately be able to achieve!”

The construction of the HPQ building has been made possible thanks to a generous donation from ETH alumnus and Honorary Councillor Martin Haefner. The Chairman and owner of AMAG regularly supports ETH Zurich with generous donations that enable the university to achieve its strategic goals.

“For me, it’s about Switzerland as a research location. I support ETH Zurich in order to facilitate innovation and progress.”

Martin Haefner

1. Entrance
2. Hall
3. Physics laboratories
4. Low-temperature laboratories
5. Nanotechnology and materials growth technology platforms
6. Center for Low Noise Experiments (CLNE) technology platform, with
7. 120-ton concrete plinth


THANK
YOU!
ETH Zurich / Gerry Amstutz

Your contribution to our future

Science and technological innovation are more important than ever. We need answers to challenges that affect us all: from climate change to our health. The keys to success are exceptional talent, excellent research and teaching, strong partners – and you. **Help support talent and research at ETH Zurich.**

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