QUANTUM TECHNOLOGIES

Your Company's Ultimate R&D Location

Switzerland Innovation Park Innovaare

INNOVATION'S LONG-RANGE EFFECT

QUANTUM TECHNOLOGIES, DETECTOR & ELECTRONICS DESIGN, CRYOGENICS, INTEGRATED PHOTONICS

SWITZERLAND INNOVATION
PARK INNOVAARE

OUR GOAL

To create a thriving ecosystem in the high-performance computing and quantum industry within the heart of Switzerland, focusing on the following competencies:
- Quantum Technologies
- Detector Design and Electronics
- Cryogenics
- Integrated Photonics
- Materials characterisation

At Park Innovaare, the main focus lies on the following technological areas:
- Smart (Quantum) Sensors & Electronics
- Photonics
- Energy and Sustainability
- Quality Control and Security Tools
- Data Processing, High Performance Computing and Quantum Computing

How?

In collaboration with its strategic research partners - the Paul Scherrer Institute (PSI), ETH Zurich (ETHZ), EPF Lausanne (EPFL), the University of Applied Sciences Northwestern Switzerland (FHNW) – Switzerland Innovation Park Innovaare helps large companies, SMEs, and start-ups gain a competitive advantage via interdisciplinary collaboration, technology and knowledge transfer, networking, and business development consultin.

»THE RECENT FLATTENING OF THE MOORE'S LAW CURVE AND SLOWING PROGRESS IN INDUSTRY 4.0 CALLS FOR INNOVATIVE TECHNOLOGIES, TO ENABLE PREVIOUSLY UNKNOWN CAPACITIES AND ENSURE THE NEXT STEP IN TECH EVOLUTION. IN COLLABORATION WITH ITS STRATEGIC PARTNERS, SWITZERLAND INNOVATION PARK INNOVAARE IS UNIQUELY POSITIONED TO ENABLE THE SUCCESSFUL IMPLEMANTATION OF THE QUANTUM COMPUTING REVOLUTION IN EUROPE.«

— Benno Rechsteiner, CEO Park Innovaare

WHERE?

Park Innovaare, one of six Switzerland Innovation network sites, is located in the Canton of Aargau, close to Zurich Airport, EuroAirport Basel-Mulhouse-Freiburg and the German border.

The Park Innovaare mandate is to promote innovation through improving knowledge and technology transfer from the research institutions of the ETH Domain through increased interaction between researchers and Park Innovaare's member companies. The ETH Domain comprises two leading universities and four research institutes, of which The Paul Scherrer Institute (PSI) is one. At the PSI and by extension within the Park Innovaare campus, residents will have the opportunity to meet and interact with many professors from across Switzerland and Europe who use the large-scale facilities of PSI for their research in the areas of Advanced Materials, Micro- and Nanotechnologies, Quantum Technologies, Cryogenics, as well as Novel Imaging Solutions, to name but a few.

In addition, Park Innovaare is located close to its other strategic partner, the University of Applied Sciences Northwestern Switzerland (FHNW), one of Switzerland's leading universities of applied sciences. Both innovative and praxis-oriented, the FHNW is a much sought-after partner for industry, with its applied and economically validated industrial expertise complementing PSI's fundamental research capabilities.

Both partners are champions in a multidisciplinary approach, thereby enabling any project to be the starting point of a far-reaching technological journey – starting at fundamental physics and continuing to prototype creation, validation, development, automation, and scaling up.

ETHZ | Swiss Federal Institute of Technology Zurich (QS World, 6th, 2020)

EPFL | Swiss Federal Institute of Technology Lausanne (QS World, 18th, 2020)

PSI | Paul Scherrer Institute

Empa | Swiss Federal Laboratories for Materials Testing

WSL | Swiss Federal Research Institute for Forestry, Snow and Landscape

Eawag | Swiss Federal Institute for Water Resources and Water Pollution Control

ETH Eidgenössische Technische Hochschule Zürich Swiss Federal Institute of Technology Zurich

EPFL

PAUL SCHERRER INSTITUT PSI

Empa Materials Science and Technology

WSL

eawag aquatic research

SWITZERLAND INNOVATION
PARK INNOVAARE

Switzerland-wide Research Network — ETH Domain:

1 — PAUL SCHERRER INSTITUTE

Is our partner and neighbour and conducts cutting-edge research in the fields of matter and materials, energy and the environment and human health. By performing fundamental and applied research, PSI works on sustainable solutions for the major challenges facing society, science, and the economy. Its globally unique combination of 5 large-scale research facilities on one campus, combined with teaching activities at universities throughout Switzerland enables cutting edge research. PSI is the largest research institute for natural and engineering sciences within Switzerland. ETH Zurich and EPF Lausanne are two universities of the ETH Domain, which are tightly linked to the Paul Scherrer Institute PSI through common research areas and shared professorships.

2 — ETH ZURICH

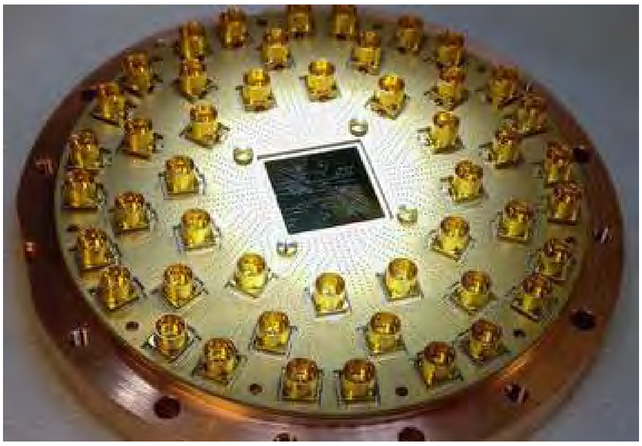
The Swiss Federal Institute of Technology Zurich (ETH Zurich) is located only 38km from Park Innovaare. The ETH Zurich is a worldwide leader in many areas including:

— Quantum Science and Technology
— Quantum Electronics
— AI Computer Sciences
— Information and Communication
— Systems & Software Engineering

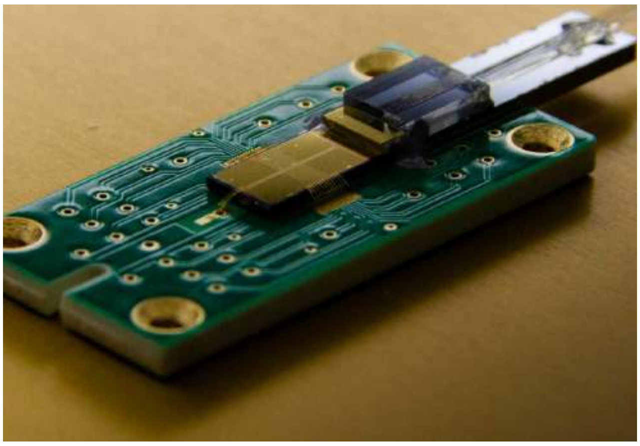
3 — EPFL

The Swiss Federal Institute of Technology Lausanne (EPFL) is home to over 350 laboratories and research groups, each working at the forefront of science and technology. Their goal is to better understand and improve our world. EPF Lausanne is a leader in the areas of:

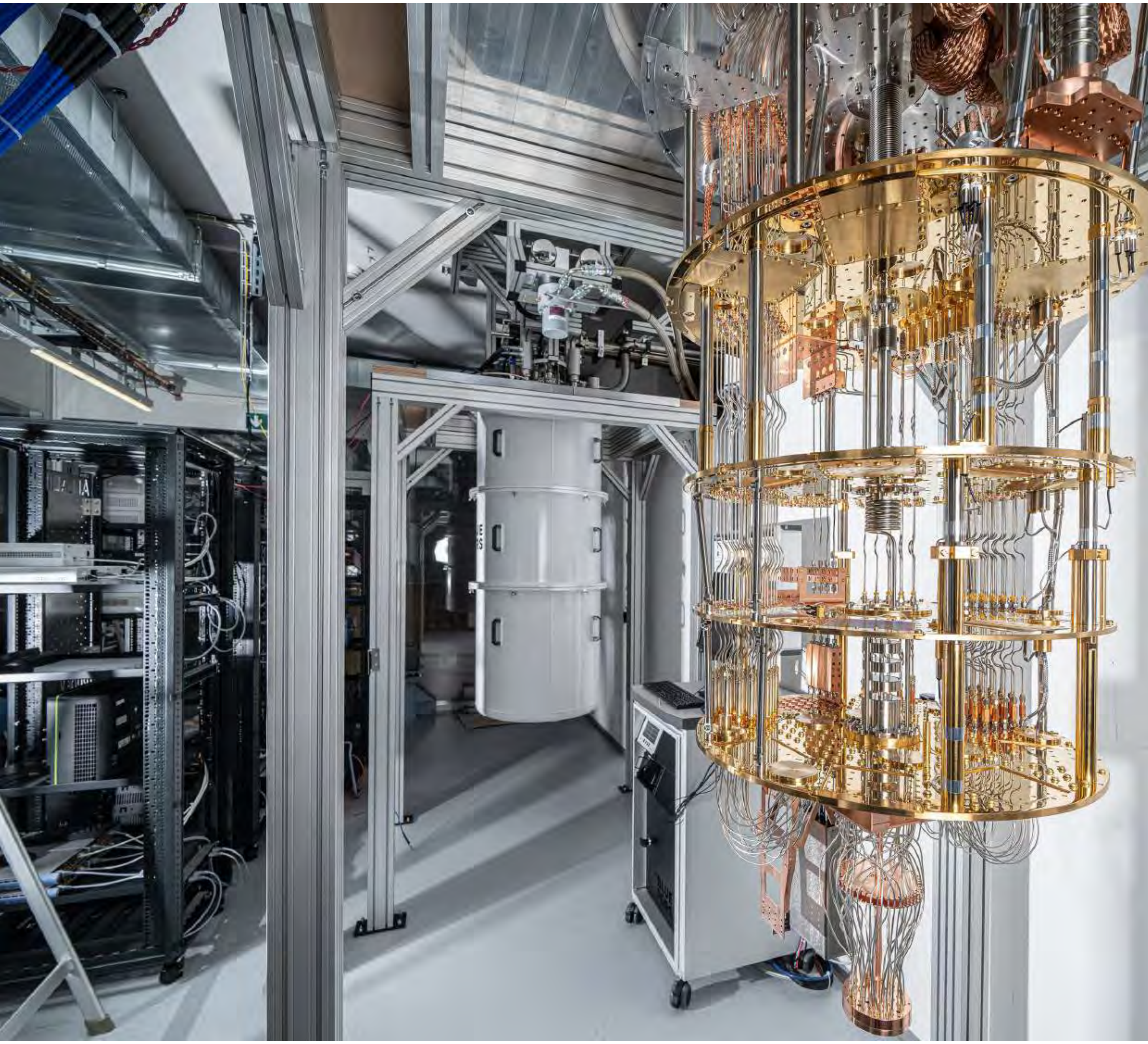
- Computer and Communication Sciences
- Quantum Science and Technology
- Data Science and Learning
- Photonics, Optoelectronics & Quantum Optics



Superconducting quantum chip with 17 qubits mounted in a fixture with 48 control lines | ©Quantum Device Lab/ETH Zurich



Ion trap with integrated optics for quantum computing | ©Karan Mehta/ETH Zurich



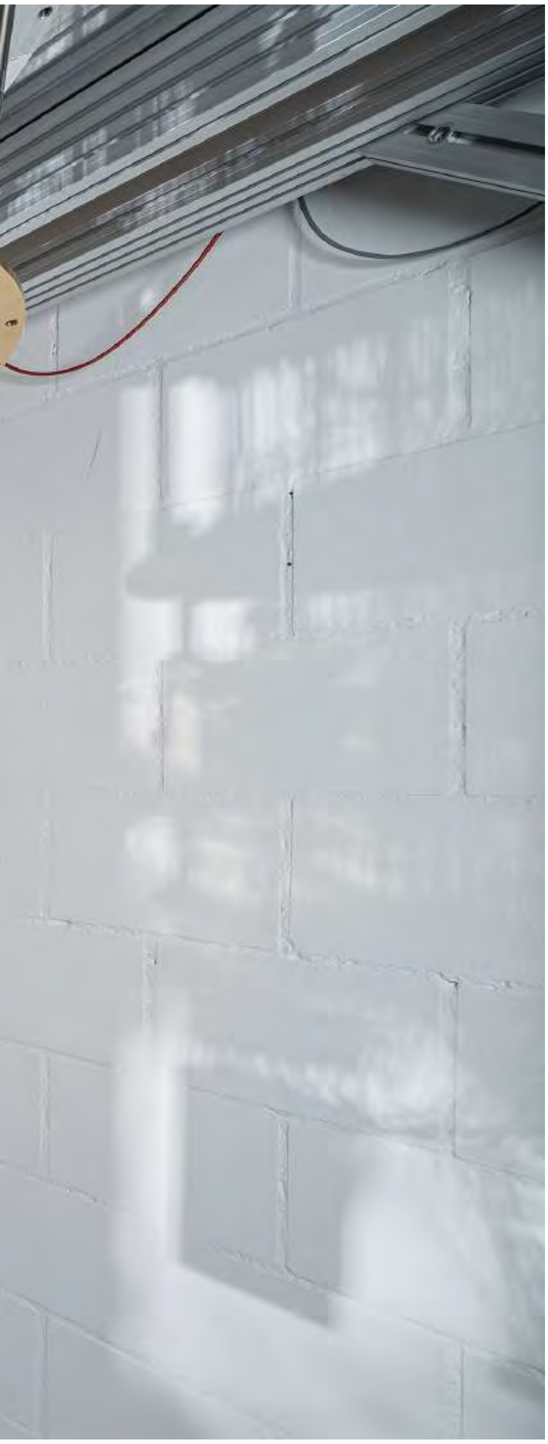
The Quantum Computing Hub (QCH) at PSI:

is located on the PSI campus and was founded as a joint initiative between ETHZ and PSI. Research groups established at PSI work on different types of quantum computing, including ion-trap, neutral atoms, and superconducting qubits. The QCH exploits PSI's know-how in the implementation of large-scale research projects, in the extremely precise measurement methods developed at its large-scale research facilities, along with PSI's cryoelectronics, and nanofabrication know-how. It builds upon the extensive developed at the Quantum Device Lab (QuDev) and Trapped Ion Quantum Information Group (TIQI) located at the ETHZ to achieve:
— Scaling up to larger scale systems of tens of fully error corrected **qubits***
— Advancing materials and control, and
— Exploiting the synergies across technologies and the software stack.
— Nanofabrication capabilities tailored to quantum technologies in state-of-the-art cleanroom

The Division of Scientific Computing, Theory and Data at PSI:

has been built with help of the second large player in the Swiss Quantum Space, the EPFL in Lausanne, and pools together all the existing capabilities and equipment in this area, which is leveraged by the scientists and users at the large scale facilities.

***Fully error corrected qubits** maintain **connectivity** and **quantum coherence** across all qubits. In order to run a meaningful calculation in a multi-qubit-system all qubits have to be able to talk to each other. During such information-swapping processes, the errors of the single qubits accumulate, where the error of the worst qubit dominates. The solution for this issue is "Quantum Error Correction", where physical qubits become virtualised as one logical qubit. The teams at ETH Zurich behind Prof. Andreas Wallraff and Prof. Jonathan Home are world leader in building the largest numbers of quantum corrected qubits.



Superconducting circuit and trapped ion quantum computing hardware
© ETHZ/PSI Quantum Hub Jonathan Home, Andreas Wallraff, Cornelius Hempel

A GROWING INNOVATION CAMPUS

At Park Innovaare, high-tech companies will be given the opportunity to develop and expand within a dynamic and innovative ecosystem, which is supported by an exceptional pool of talent, a portfolio of services, an outstanding scientific network located on site, and the industrial landscape of the surrounding Canton of Aargau.

Park Innovaare celebrated the topping-out of the brand-new, modern innovation campus buildings in September 2021, less than two years after the ground-breaking ceremony and despite the pandemic hanging over the world.

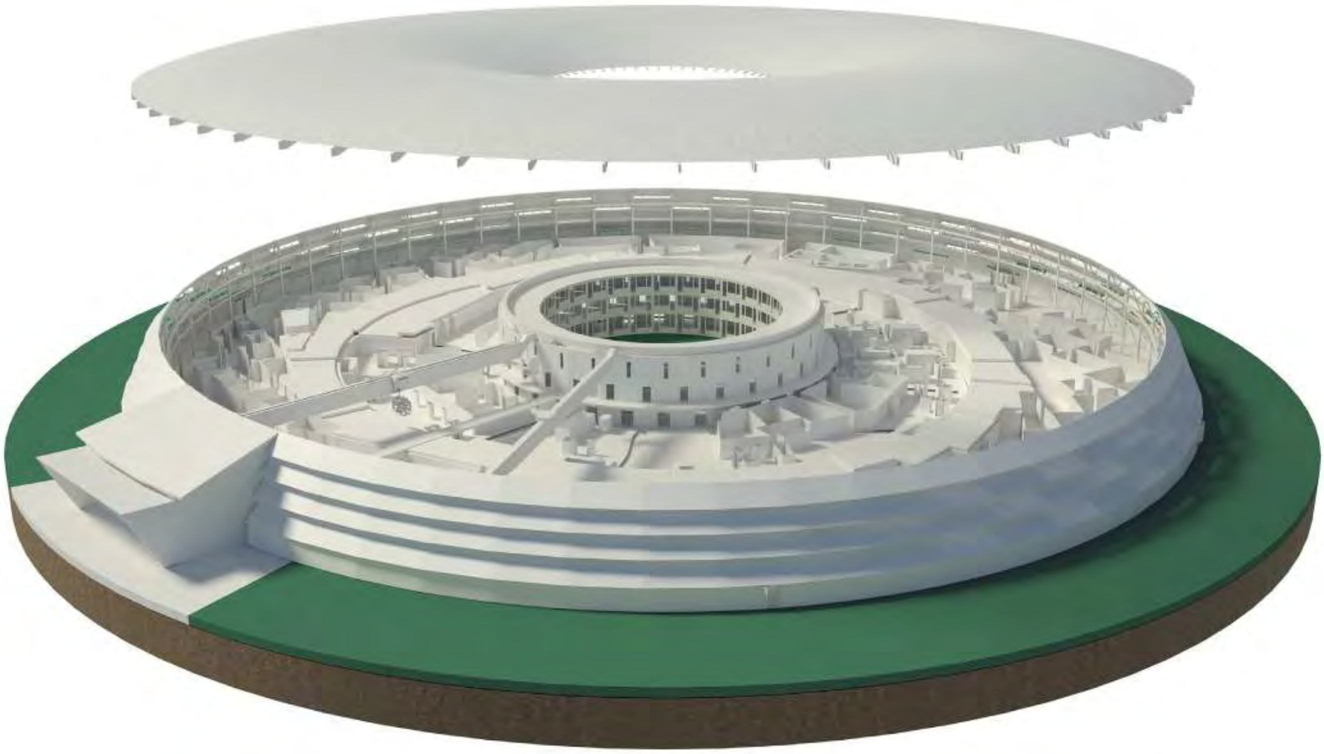
Its buildings are specifically tailored for industrial research and development and designed to meet the needs of its current and future member companies.

The final technical inspection and approval of the buildings is scheduled for 2023, after which the campus will enclose a useable surface area of approximately 23,000m2, complete with customisable laboratories, vibration-free areas meeting VC-E criteria, cleanrooms (compliant with ISO 5 & ISO 6 standards), prototype workshops, meeting and conference rooms, as well as an in-house refectory just across the street from PSI. An additional point to note is that a site for expansion and to build an additional 46,000m^2 of innovation space has already been acquired.

Simulation Park Innovaare | ©Park Innovaare


Park Innovaare | ©PSI


Park Innovaare | ©PSI



Swiss Light Source as 3D graphic. | ©PSI/Mahir Dzambegovic

SHARING FACILITIES WITH PSI'S **PHOTON SCIENCE & ACCELERATOR DIVISIONS**

Core research competences at the Paul Scherrer Institute (PSI) include advanced materials, quantum technologies, machine learning and high-performance computing algorithms. The institute's large-scale research facilities, including the Swiss Light Source (SLS), globally one of the most highly regarded light sources, as well as the Swiss Free Electron Laser (SwissFEL), the Swiss Spallation Neutron Source (SINQ) and the Swiss Muon Source (SMUS) provide various analytical methods and highly intense beams of particles – photons, neutrons, and muons. This allows material characterisation down to the smallest scale, including the measurement and characterisation of magnetic phenomena, spintronics, super- and semiconductors, as well as quantum materials. Park Innovaare and its member companies, such as ANAXAM, Excelsus and Expose, provide consultancy services and easy access to the advantages of the scientific facilities, exploiting the right machines, particles, and methods. This can also include operando spectroscopy or 3D computer tomography scans of large (e.g. electrical motors and components of fusion reactors) and small objects (e.g. semiconductor chips, ASICS, or protein structures).

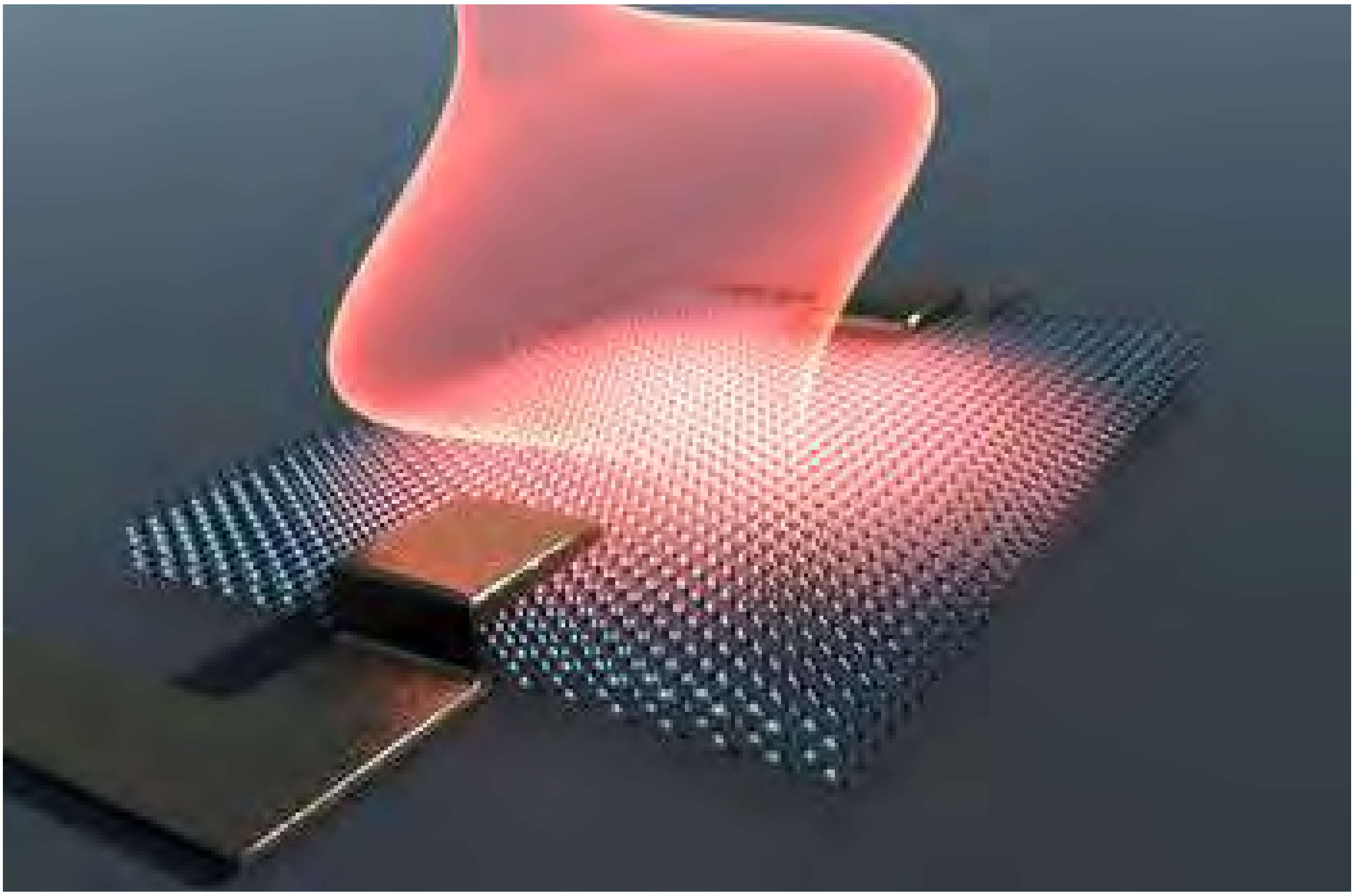
By locating at Park Innovaare, high-tech companies working in the field of quantum or information technologies will occupy the same building as PSI's Photon Science and Accelerator divisions and will be able to access the laboratories and workshops operated by PSI, including state-of-the-art cleanrooms and prototyping facilities. The aim of such proximity is to facilitate the exchange of ideas and optimise the cross-fertilisation of technological solutions

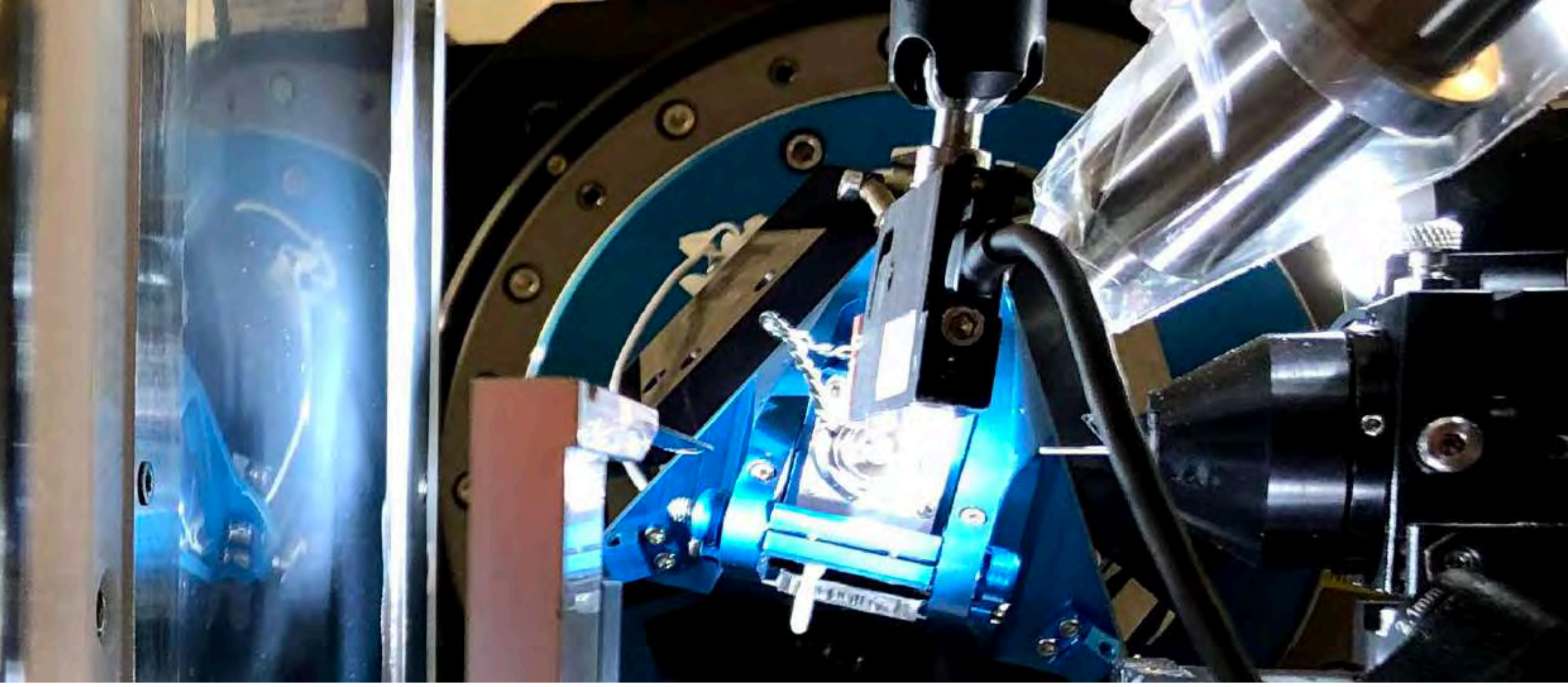
Quantum Technologies

One of the main driving forces for top-down nanofabrication is to design the light-matter interaction in metamaterials, to improve their optical and transport properties by applying quantum effects and controlling external constraints such as spatial dimension and strain. PSI's scientific agenda is to develop new concepts based on quantum science and technology, evolving from the immense know-how of classic materials and correlated electron systems developed over decades of research. Scientists at PSI are working on many projects with disruptive potential including 2D semiconductor devices, charge density wave (CDW) based memory devices, imaging of quantum many-body states, nonlinear magnonics, and rare-earth quantum magnets. The investigation of future quantum systems is supported by the theoretical and computational exploration of correlated quantum matter as well as atomic, molecular, and optical (AMO) systems.

Spectroscopy and scattering techniques are the main tools investigating the respective "modified" structures, which provide the basis for improving the performance of novel electronic and optoelectronic devices.

The unique combination of different labs and facilities creates new ways for investigating the fundamental quantum aspects of matter, as well as to store and manipulate quantum information with the goal of exploring both quantum computation and simulation.





Set-up of the novel Jungfrau detector during tests at the beamline | ©PSI/Vincent Olieric

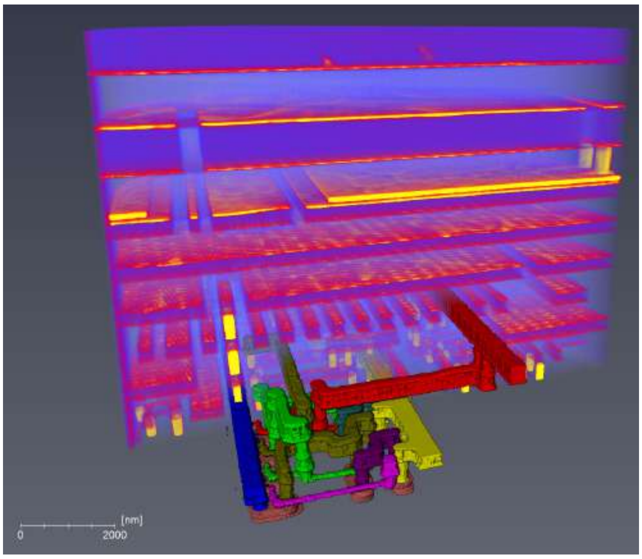
Detector Design and Electronics

PSI is a leader in nanotomography and holds the world record for time-resolved tomography. This is made possible by detectors and sophisticated algorithms developed by researchers at PSI.

The Detector Group of the Photon Science Division has a long-standing history in the development of single photon counting X-ray hybrid detectors for synchrotron applications. The group works on the optimisation of position resolution by reducing pixel size and using the charge sharing effect to obtain maximum information about the absorption position of the photon, as well as working on new sensor materials to increase efficiency at higher energies by using high-Z sensor materials (CdTe) or thick Si sensors.

The Group Electronics for Measuring Systems develops Detector and Sensor Readout units and Data Acquisition Systems to allow for measurement and counting of particle-matter interaction signals caused by charged and neutral particles as well as photons. It also offers services and support for Electronic System Designs, Printed Circuit Board Designs, Chip Designs and Electronics Education Services. The expertise of these two groups combined can support the development of any detector system, including the highly sensitive single photon time-correlated low noise fast read-out detectors needed for quantum technologies. The most prominent spin-off from the PSI in this area is the company DECTRIS, which provides reliable and fast single photon counting detector solutions to research facilities all over Europe.

Furthermore, the sensor groups at PSI and FHNW employ machine-learning algorithms and artificial intelligence in areas ranging from material sciences to medical data processing. An excellent example of this approach can be observed in a project at the Institute for Sensors and Electronics, where machine-learning algorithms are implemented within a field-programmable gate array (FPGA), enabling parallelism as well as a flexible and energy-efficient approach to algorithm deployment for large projects.



Ptychographic X-ray computed tomography image of a detector ASIC chip ©PSI/Mirko Holler

Cryogenics

Cryogenics are highly important for quantum technologies. Just recently the Quantum Computing Hub at PSI reported its first success with superconducting qubits. To be able to build, maintain and operate five large-scale facilities at one site, PSI's scientists and technicians have had to become masters in prototyping – from the nanoscale to kilometre-sized facilities. One of these areas of expertise is cryogenics, as this is often needed to provide the right conditions for experiments at the Swiss Neutron Source (SINQ), the Swiss Light Source (SLS) and the Swiss Free Electron Laser (SwissFEL), where parts or samples must be cooled down to almost absolute zero.

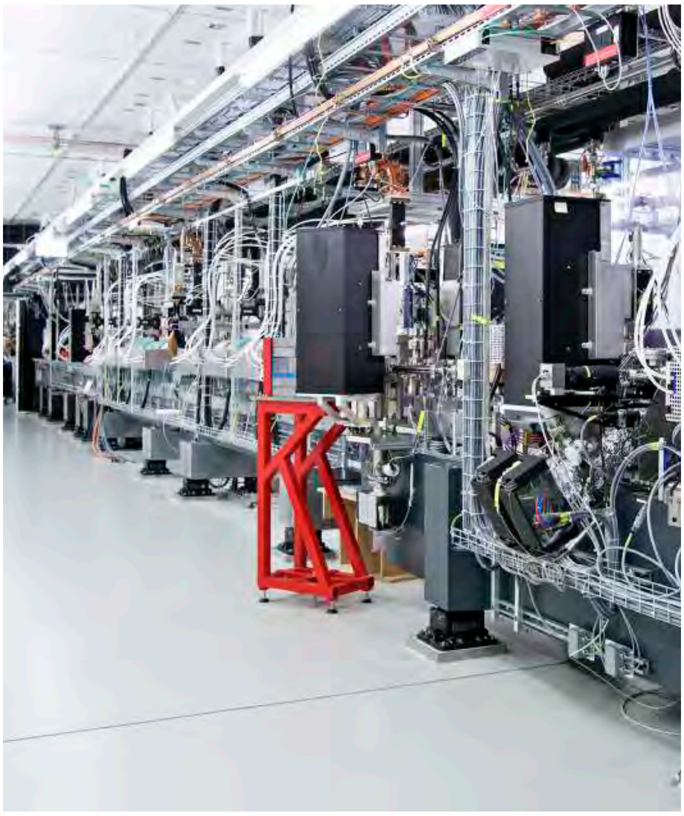
The Mechanical and Electrical Engineering Group has long experience in the design of scientific instruments, especially cryogenic systems. They will move into Park Innovaare together with the Photon Science Division and provide support to other groups in the design, initial developments and preliminary studies of technical prototypes, production, assembly, maintenance, and repair of the instruments, e.g. to the Sample Environment Group, which designs sample environments to precisely control environmental parameters (e.g. temperature, magnetic field, pressure, etc.), all of which are essential to study phenomena such as magnetism or superconductivity.

This expertise also facilitates research on conventional superconducting devices, e.g. the Group of Insertion Devices and Magnet Section Group are respectively replacing the conventional magnetic parts of the SLS with cryogenic permanent and high-temperature superconductive magnets to generate X-rays with up to 1000 times higher brilliance and cryogenic superconductive accelerator magnets with high field strength for the SLS upgrade.

Expertise in cryogenics and the associated achievements in superconductivity allow for further studies of related phenomena. The Laboratory of Scattering and Imaging researches superconductivity and induced magnetism in Cerium-Cobalt-Indium. The unconventional superconductivity of KV3Sb5 is under scrutiny in the Laboratory for Muon Spin Spectroscopy, as it exhibits a giant quantum anomalous Hall effect below 80 Kelvin, which might open doors to novel quantum devices.

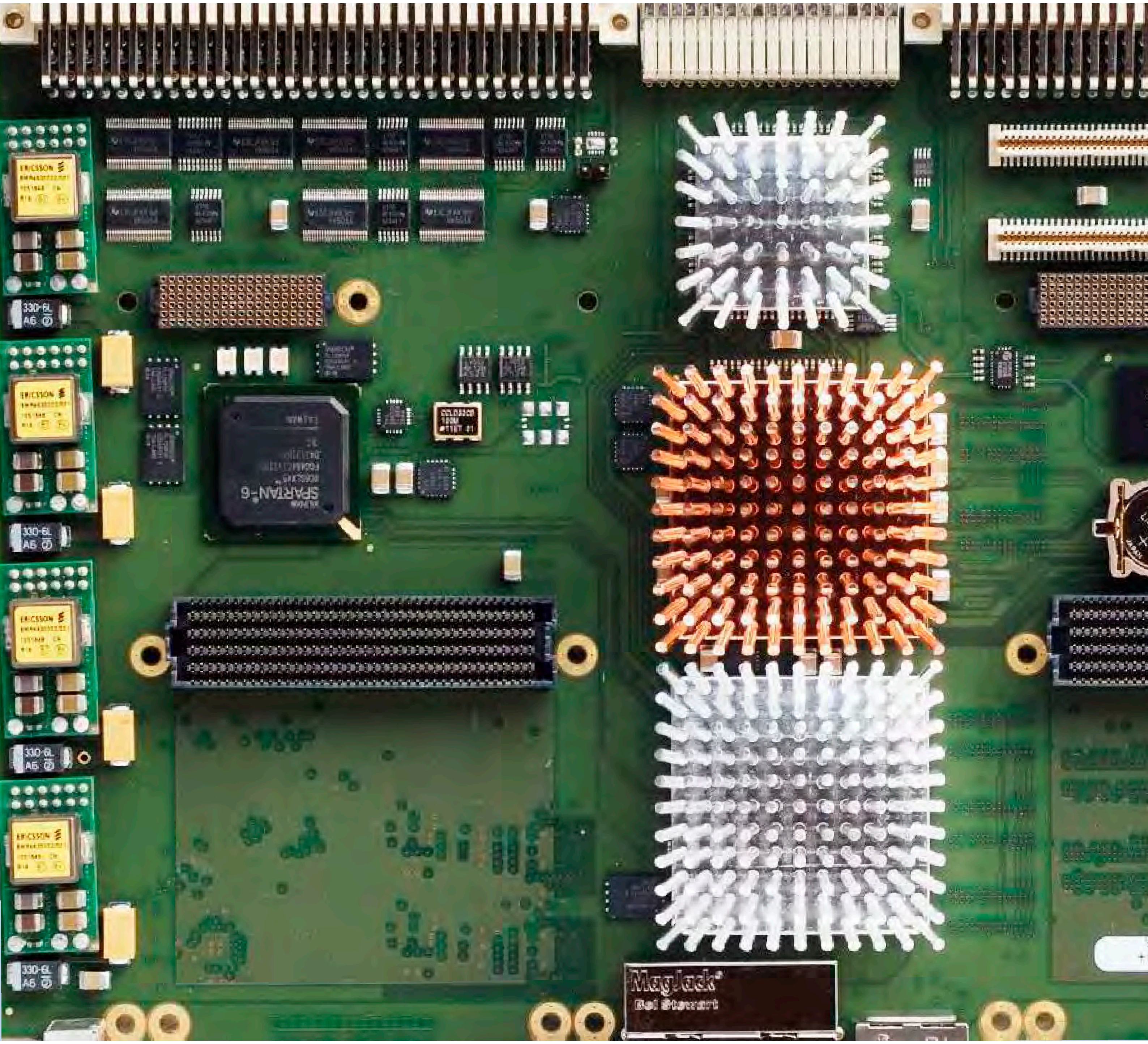
The start-up company CondenZero, a spin-off company from the University of Zurich, is also located at Park Innovaare. It offers a liquid helium cryo-TEM sample holder with a temperature of 4.4K, a cooling time of less than 15 minutes and a holding time of more than 24 hours. A living example of cryogenic expertise becoming a product.

Filling of a DEWAR with liquid nitrogen



SwissFEL – Injector | ©PSI/Markus Fischer


DRS 4 – custom IC developed by PSI | ©PSI/Stefan Ritt

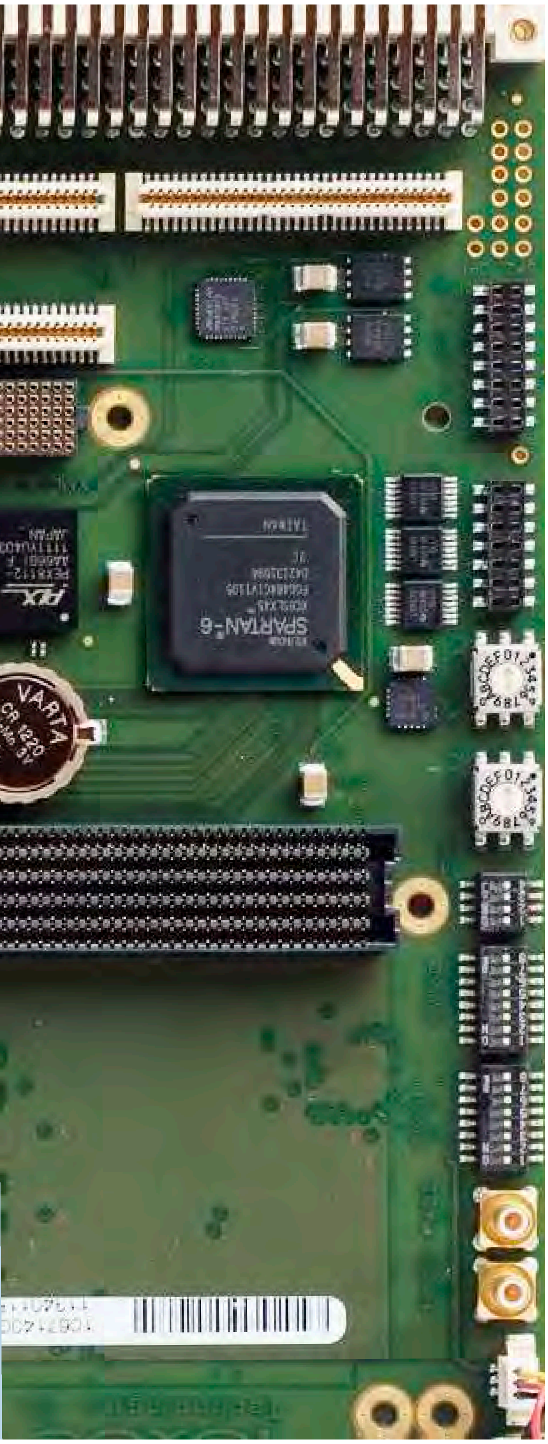


Integrated Photonics for Quantum Technologies

The new Laboratory for Nano and Quantum Technologies (LNQ) at PSI has the following main areas of research:
— Nanotechnology,
— Advanced Manufacturing,
— Ion-trap Quantum Computing,
— Superconducting Circuit Quantum Computing and,
— Quantum Engineering.
It is dedicated to fundamental and applied research, focusing on the synergies of nanotechnology and quantum science. It provides advanced micro and nanofabrication technologies to academic and industrial users, particularly in the areas of quantum technology and X-ray instrumentation, as well as developing quantum technologies for quantum computing.

The group leverages experience from the Laboratory for X-ray Nanoscience and Technologies (LXN), whose mission is to perform fundamental and applied research focused on nanoscience by leveraging the synergies between advanced micro/nanofabrication and large-scale facilities. LXN holds, amongst other accolades, the world record in resolution for photolithography down to 6 nm half pitch. LNQ benefits from the specialized Quantum Photon Science group within LXN, which uses the light-matter interaction in metamaterials to improve the optical and transport properties of materials through the targeted application of quantum effects, as well as through the control of external constraints such as spatial dimensions and strain. Spectroscopy and scattering techniques are the main tools for investigating the respective "modified" structures, which provide the basis for performance improvements of electronic and optoelectronic devices.

The combined power of these two groups embedded within the large-scale facility ecosystem gives rise to research projects on X-ray quantum optics, compact quantum computers, ultrafast control of quantum materials and many more. These topics in turn could help optimise quantum devices and computers, bringing the quantum age closer.



Single Board Computer – IFC-1210 |
©PSI Fenster zur Forschung

info image

FUNDING

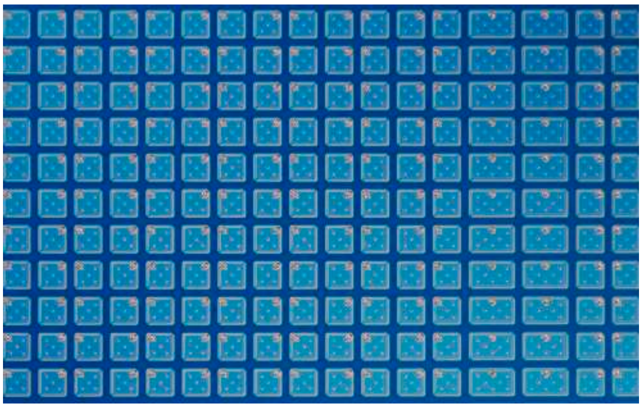
Park Innovaare, its network, and, by extension, all its Member Companies, profit from interconnection and support at international, federal, and cantonal levels.

At the federal level, fundamental research projects can apply for funding from the Swiss National Science Foundation (SNSF) and innovation projects can participate in the Innosuisse programme. The Canton of Aargau offers its own research and development support programmes such as Nano Argovia and other funding opportunities through various foundations.

Furthermore, should a company be interested in acquiring specific research equipment, it can be purchased by Park Innovaare and hired out to the company for its own use. The funding must be obtained from the federal innovation fund and needs approval. However, this option allows a company to have access to expensive equipment with no upfront costs and to have the actual cost of use distributed over time.

Tax deduction of research and development costs is another benefit of the location, as it is part of the cantonal support for industrial level research and development activities. Several of Park Innovaare's network partners can assist in this area should the need arise. Park Innovaare belongs to an extensive industrial and academic network, which facilitates access to further internal and external funding instruments, including venture capital.

When compared with companies choosing to collaborate remotely on a per-project basis, high-tech companies located at Switzerland Innovation Park Innovaare in the Canton of Aargau benefit from a clear competitive advantage in terms of access, knowledge transfer and speed of research and development. Why? Because they can work alongside researchers and scientists affiliated to PSI's Photon Science and Scientific Computing, Theory and Data Divisions as well as in proximity to the University of Applied Sciences & Arts Northwestern Switzerland FHNW, to the ETH Zurich as well as the university hospitals located in the Zurich and Basel areas.



A chip from a detector developed by Dectris | ©PSI/Dectris

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Innosuisse – Agence suisse pour l'encouragement de l'innovation

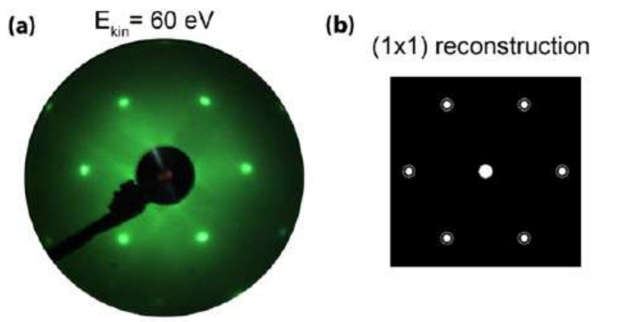
SNI
Swiss Nanoscience Institute
Exzellenzzentrum der Universität Basel und des Kantons Aargau

Schweizerischer Nationalfonds

A QUANTUM SUCCESS STORY FROM THE PSI'S QUANTUM TECHNOLOGIES GROUP

Compact Quantum Computers via Topological Qubits

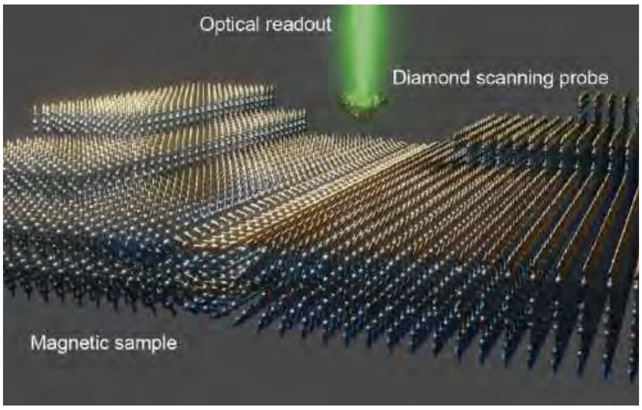
Scientists from PSI in collaboration with Microsoft have published their latest research on topological qubits, which have the potential to prevent leakage of information and thus to be used to build a slim quantum computer. Specifically, at the ends of nanowires Majorana-fermions can be induced by coating opposite ends with superconductor and natural oxide. Through the combination of synchrotron based experiments and simulations, scientists at PSI could show that indium antimonide is a very promising material for the creation of such topological qubits. The identification of such materials is the next step in building a functioning slim quantum computer.



(a) Low-energy electron diffraction (LEED) results for InAs(111);
(b) A simulated LEED pattern corresponding to 1x1 surface (Shuyang Yang et al., Adv Quantum Tech, Volume: 5, Issue: 3, First published: 20 January 2022, DOI: (10.1002/qute.202100033))

A success Story from ETH Zurich – Diamond Probe Scanning

The Diamond Lab at ETH Zurich explores spin defects in semiconductors. Such effects can lead to development of novel sensing applications, which can be used in nanotechnology and other areas of scientific research. If a nitrogen atom is incorporated as a defect in a diamond lattice, a nitrogen-vacancy centre (NV centre) is created, which is a single-spin system and can be accessed and read out at room temperature with simple optics. As spin systems are sensitive to magnetic fields, such an NV centre can be used as an excellent sensor with very high spatial resolution for the exploration of weak magnetic features. The Diamond Lab at ETH Zurich uses techniques from quantum metrology to develop experimental tools and methodologies to access such magnetic phenomena, which cannot be determined with existing magnetic probes.



Artistic view of diamond probe scanning an antiferromagnetic sample (courtesy of ETH Zürich, Spin Physics Group and M. Wörnle)

INNOVATE WITH US

Benefits awaiting your Company include ...

INFRASTRUCTURE
Proximity to the Photon Science Division of the Paul Scherrer Institute (PSI).

ENTREPRENEURSHIP
Breakthrough technologies introduced into industry through state-of-the-art spin-offs & start-ups.

FUNDING
Access to research funding, investors & venture capital.

ACADEMIC EXCELLENCE
Collaboration with world-class academic partners. Easy access to highly-qualified talent & researchers.

INNOVATION SERVICES
Most innovative country in the world. Industrial liaison officers to support R&D projects.

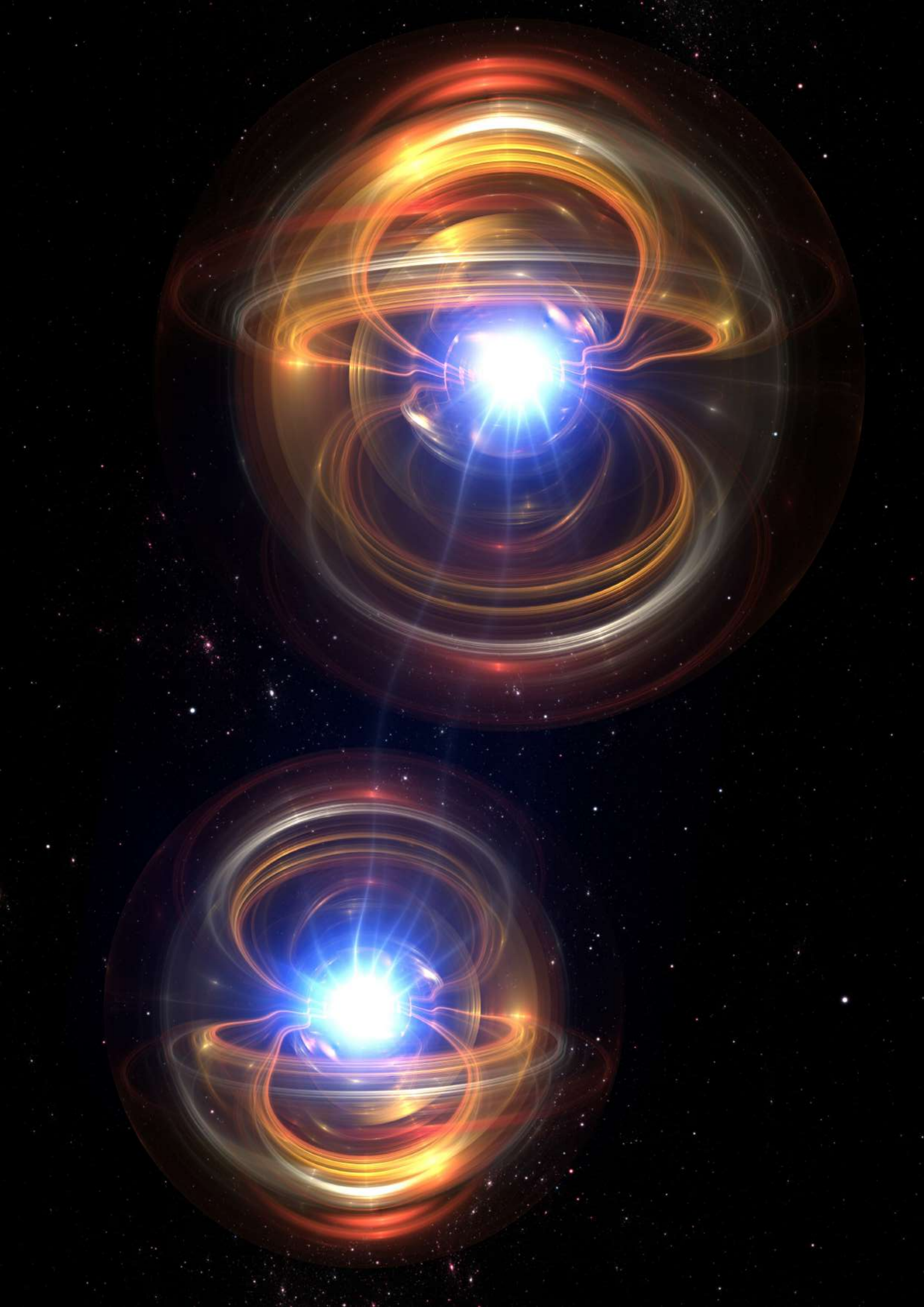
INDUSTRIAL PARTNERSHIPS
PSI and FHNW have a long history of efficient technology and know-how transfer with companies worldwide.

SCIENTIFIC TOOLS
Access to scientific labs and tools (HPLC, TEM, SEM, AFM and more). Introduction and support for novel methods.

SWITZERLAND
High quality of life, political stability, attractive living environment. Centre of Europe.

BUSINESS
Efficient government infrastructure with favourable conditions for new businesses.

INTERCONNECTION VIA PARK INNOVARE
Contacts with scientists at PSI and FHWN as well as industrial partners. Connection with problem-solvers at cantonal and national level. Evaluation of funding possibilities



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