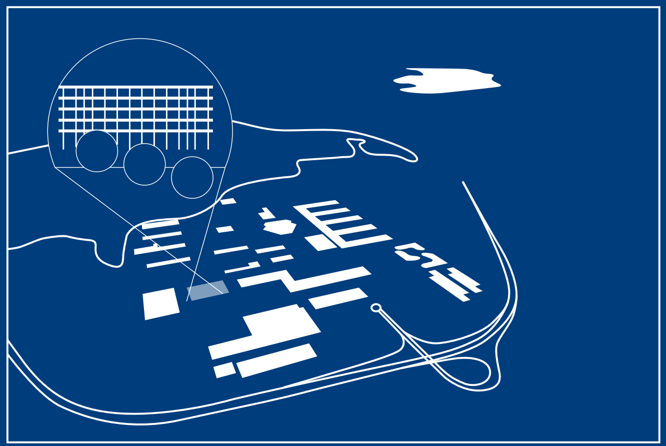
ETH zürich

The HPQ project

A perspective by its future users

Department of Physics



Captions for central pages 6 & 7:
Aerial view of the ETH Hönggerberg Campus from north-west. The city of Zürich with the lake and mountains appear in the background.
Top left inset shows the HPQ façade from the south-east; white lines connect to the actual position of the building in the campus.
Three lenses show scanning and transmission electron micrographs of a mesoscopic structure in physics, liver capillaries in biology, and a magnesium alloy in materials science.

credits: ETH Zürich / Alessandro Della Bella

Physics: Scanning Electron Microscope (SEM) picture of a mesoscopic device fabricated in the FIRST lab. The rake-like structure at the bottom confines an electronic whispering gallery mode, while the 4 fingers hold a quantum dot (artificial atom) at their bottom end. The structure serves to connect dot states via the gallery mode (Ensslin group, ETH Zürich).

Biology: Scanning electron micrograph of blood capillaries in the liver (mouse), serving a study of the University Hospital Zürich on liver transplantations. The capillaries are openly exposed, providing visible access to the inner walls. The lower capillary holds a stack of red blood cells. Liver cells (hepatocytes) have remained intact, with the cleavage plane running between cells (courtesy Dr. Anne Greet Bittermann, ScopeM, ETH Zürich).

Materials: High-resolution TEM micrograph of a new magnesium alloy (MgZn1.5Ca0.3 or ZX20) for biodegradable implants, e.g., cardiovascular stents. The nanometer sized Ca- and Zn-rich precipitate in the center serves to enhance the material's strength and ductility, and to tailor its degradation behavior. The feature in the lower left is an irradiation-induced dislocation loop (view parallel to the loop) that visibly grows during the exposure time (Löffler group, ETH Zürich).

Editorial

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Continuing to shape the future of our society through science and technology

Our technology-driven society is built on basic foundations, concepts, and technologies created by science and engineering. Steam engines (thermodynamics) were central to the first industrial revolution, and steelmaking (materials science), electrification (electrodynamics), and chemical synthesis (chemistry) to the second. The rise of electronics has then initiated the third revolution, with computing and communication as its defining technologies, in conjunction with the development of biotechnology (biology).

Today, we are at the dawn of the fourth industrial revolution, driven by digitalization, data, and the Internet, as well as by advances in the biomedical sector. Central scientific and technological pillars of this next epoch will be quantum science and nanotechnology. Addressing the challenges and exploring the opportunities will require, more than ever, concerted cross-disciplinary efforts, together with an infrastructure to look at the smallest building blocks of materials and biological systems, to understand the fundamental properties and behaviours of matter and fields, and to create artificial structures that become key ingredients for next-generation technology. The HPQ project is a building designed to provide precisely such a platform to researchers at ETH Zürich.

ETH Zürich, will build HPQ, for 500 scientists with labs and offices on 14'200 square meters

space for 14 research chairs, 4 junior groups, and 3 platforms

View from the south-east on the façade of the HPQ building at the Wolfgang-Pauli-Strasse (in the front). The HPQ building is embedded between the HIF (left) and HIT (right) buildings. The double height entrance involves a mezzanine (left and right). Additional four floors hold office space (at the periphery) and lab space (in the center of the building).

Infrastructure for the future

Throughout the entire history of industrial and technological development, progress was driven by the continuous investment of both individuals and the society at large into science and research.

The new labs, offices, and technology platforms in the HPQ building will define a unique infrastructure for taking the development of science and technology at ETH Zürich to the next level. The building will be located on the Campus Hönggerberg at the Wolfgang-Pauli-Strasse, the main boulevard of the campus. It will be home to 14 chairs and 4 junior research groups in experimental physics and include 3 technology platforms serving various departments at ETH Zürich.

The HPQ building	
architects	Ilg-Santer, Zürich
volume	150'000 m^3
footprint	4'780 m^2
floor area	32'600 m^2
usable area	14'200 m^2
occupancy	500
floors	9, of which 4 under ground
project cost	250 Mio CHF

A modern and inspiring work environment

The building HPQ will provide generous space for conventional laboratories and offices above ground and high-performance laboratories as well as technology platforms below ground. A separate underground building isolates the most precious lab space from the building infrastructure. The daylight offices at the periphery of the building will combine with extended social areas to generate an inspiring work atmosphere. Chemistry and preparative labs will be shared among groups, as will be other common spaces for meetings, scientific discussions, and video conferences. The combination of technology platforms, lab space, and offices in one building will ensure an optimal collaboration and exchange between the various research groups and between students, researchers, and faculty.

Platforms for leading-edge research across disciplines

Progress in science and technology is pushing the limits – devices are becoming smaller, faster, cleaner, more powerful, and more elaborate. The tools needed to design and realize these structures become ever more complex and thus are shared among numerous users. The HPQ building will host 3 technology platforms that are designed, run and used by scientists across various disciplines of natural science and engineering.

Technology platform FIRST II
The new Center for Micro- and Nanoscience FIRST II (Frontiers in Research: Space and Time) will be a cleanroom and nanofabrication technology platform that replaces the current platform FIRST (→ www.first.ethz.ch). It will serve several hundred researchers from various departments within ETH, as well as industry.

The open and communicative atmosphere will be a most valuable resource for students, fostering the exchange of knowledge and technologies and inspiring projects across disciplines. With this new platform, ETH Zürich will be in a position to push the technological envelope and train young scientists and engineers in the use of today's most advanced equipment. An underground hall with 1550 m^2 footprint will provide space for 14 cabins offering cleanroom environments of different levels.

Work under clean-room conditions in the FIRST nanofabrication facility.

Technology platform MMC
The Materials Growth Center MMC will provide the ultra-clean materials that are the basis of many devices fabricated in FIRST II. Molecular Beam Epitaxy (MBE) and Metal-Organic Chemical Vapor Deposition (MOCVD) are leading technologies for producing the materials at the core of next-generation devices, including two-dimensional electron gases in gallium-aluminum-arsenide semiconductors, Bragg mirrors for optical cavities and so-called topological insulators, a novel kind of quantum material. A hall of 350 m^2 is designed to host up to seven MBE machines and will cover the need of future generations of top-level materials scientists.

Center for Low Noise Experiments CLNE
State-of-the-art equipment enables imaging and manipulating matter on an atomic scale. Light, electron, and tunnelling microscopes provide us with unique pictures of materials, surfaces, and biological samples and offer deep insights into nature's structure.

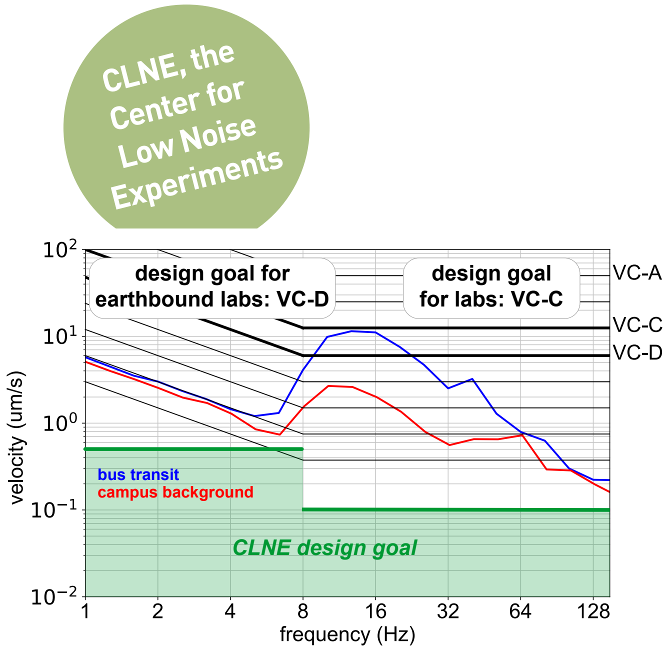
Such equipment and their future advancement requires the most protected laboratory space that can be built today, in terms of temperature- and humidity stability, as well as insulation against electromagnetic-, acoustic-, and vibrational interference. The availability of laboratory space of this grade is becoming a characteristic of the best research universities world-wide. Besides providing space for cutting-edge experiments, it is also an important asset when it comes to recruiting the best scientists worldwide. And talent, as the saying goes, attracts more talent.

Performance benchmarks (examples)	
temperature stability	< 0.01 °C
vibrational stability	< 0.1 μm/sec
magnetic-field screening	< 20 nT.

The Center for Low Noise Experiments CLNE in the HPQ building will provide 6 highest-performance laboratories as an interdepartmental platform. The labs will be arranged as separate blocks within a dedicated hall and feature so-called plinths taking up the experiments. These are floors in the form of concrete blocks, each about 100 tons in weight, suspended on air-cushions to isolate the experiments against external vibrations. The separate lab cases will each measure an area of either 25 m^2 or 35 m^2 and will be more than 7 m high to provide the space necessary for the installation of specialised equipment. Specifications are defined to be 'best possible'. Projects planned today include a setup for atomic-scale scanning tunnelling spectroscopy in the materials department, a top-of-the-line cryo-electron microscope for the ETH microscopy centre ScopeM, and a high-performance electron-beam lithography setup for the FIRST II facility.

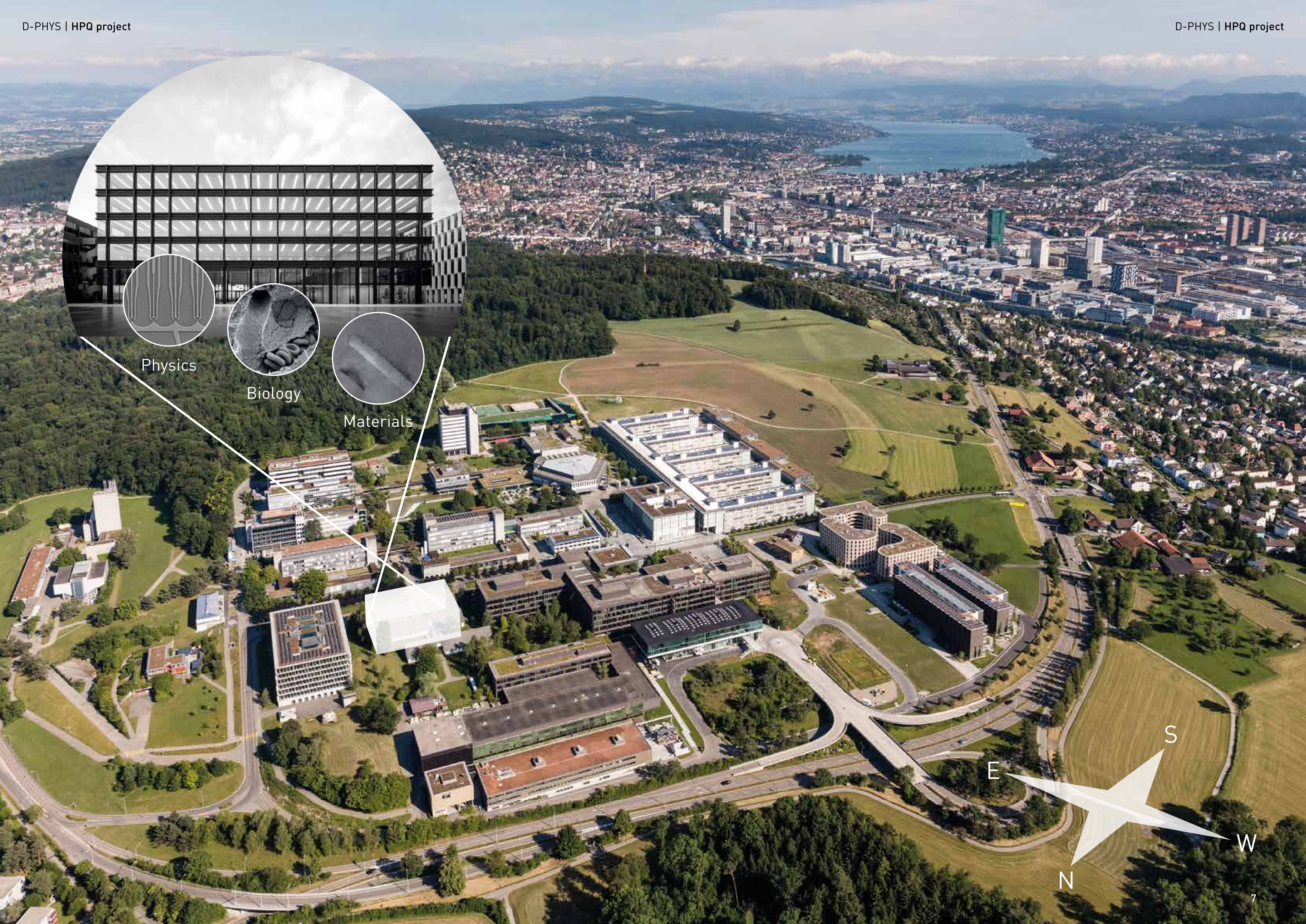
Close-up showing the buffer chamber of a molecular beam epitaxy apparatus with transfer rod (horizontal) and heating station (glowing orange) for probe cleaning. Tubes (top) provide the liquid nitrogen that cools parts in the growth chamber (Wegscheider group, ETH Zürich).

Disciplines and departments represented in HPQ	
physics	→ www.phys.ethz.ch
chemistry	→ www.chab.ethz.ch
biology	→ www.biol.ethz.ch
materials science	→ www.matl.ethz.ch
electrical engineering	→ www.ee.ethz.ch
mechanical engineering	→ www.mavt.ethz.ch



Vibration situation on campus (measured in the basement of the HIT building close to the construction site of HPQ). The plot shows the peak hold velocity third-octave spectra of the vibrations for daily normal campus activities (red) and for a bus passing (blue). The demanding design goal for the CLNE requires the vibrations in the lab to be exclusively below the green lines. Also shown are the design goals for normal labs (VC-C) and for earthbound labs (VC-D).

D-PHYS | **HPQ project**



Laboratories

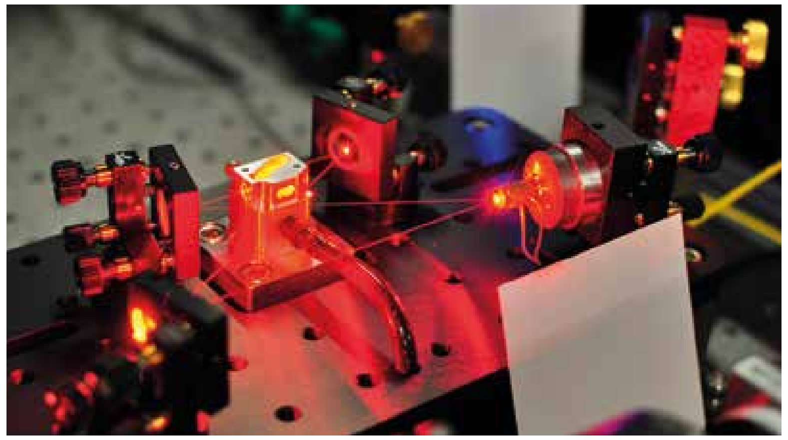
The laboratories in HPQ can be configured to have areas of 25, 50, 75, or 100 m^2 and feature a separated support area nearby to hold noisy equipment. A modular concept allows to further enhance the functionality of generic labs to serve as either optics- or low temperature laboratories. Earthbound generic-, optics-, or low temperature laboratories have special floors that passively or actively suppress or compensate vibrations.

Generic laboratories, have high specifications for vibration level, ambient magnetic fields, acoustic noise, and temperature- and humidity control. These labs have moderately high ceilings (3.8 m clear height), walls and ceilings offer ample attachment points for equipment. Temperature stability and power density are 1 K and 0.1 kW/m^2 above and 0.5 K and 0.25 kW/m^2 below ground. Nitrogen and helium gas are supplied, and helium recovery lines are installed. Magnetic noise remains below 100 nT. Generic labs are easily reconfigured and serve a large variety of different physics experiments. Low- and high frequency electron transport labs, fiber-based optics labs, most biophysics labs, most NMR labs, and materials synthesis labs are expected to be well served by this lab type.

BaBrCl crystal growing out of the melt using the Czochralski method with an inductively heated furnace. Doped crystals are used as scintillators (courtesy Dr. Yan Zewu, Zheludev group, ETH Zürich).

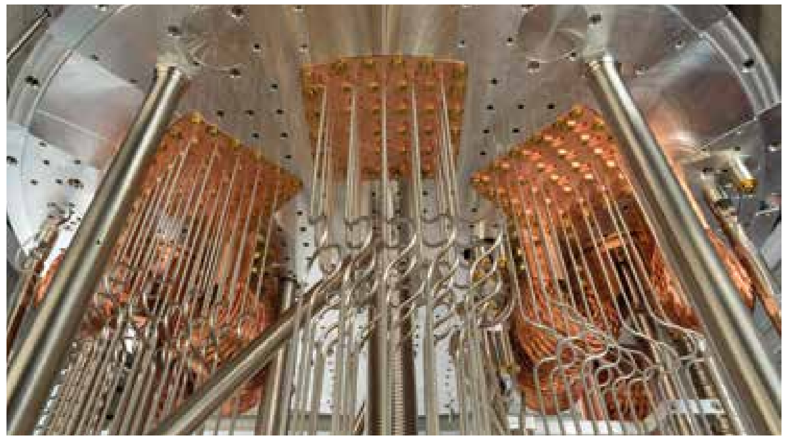
right: Top cold stage in a dilution refrigerator for quantum computing. Several such cold stages take the temperature to the 10 milliKelvin scale at the bottom. Winding tubes guide the microwave signals operating the qubits on the computing chip (Wallraff group, ETH Zürich).

Optics laboratories, have requirements beyond the generic laboratory regarding air-quality control, including temperature, humidity, particle count, as well as vibration standard. Local temperature stability better than 0.1 K over extended time scales of hours or days is frequently required. Labs are over-pressured relative to corridors to keep dust out. Filtered laminar airflow is used to keep optical elements clean and reduce thermal gradients. Mounting systems for curtains and shelves above optics tables are installed. Air locks provide safe access to the labs.



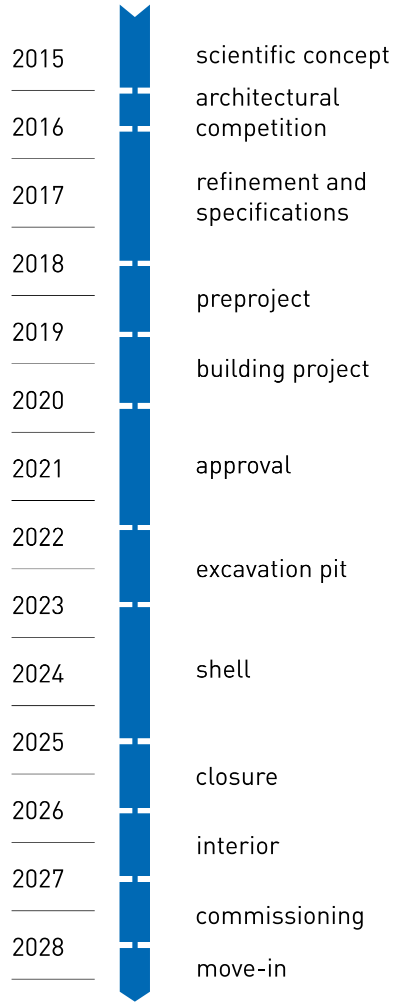
Optical setup for frequency doubling of red light with 626 nm wavelength to 313 nm (outside visible spectrum) used to cool Beryllium atoms in a trapped ion experiment (Home group, ETH Zürich).

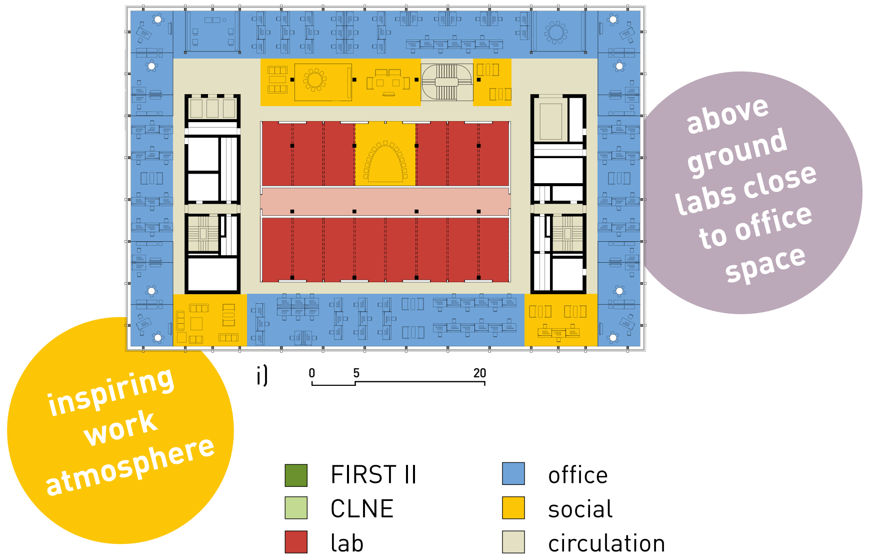
Low temperature laboratories, particularly those operating quantum-coherent electronics, need, in addition to the features found in a generic laboratory, an extremely low electro-magnetic interference (EMI) environment, static dissipative flooring, and pits integrated into the floors to accommodate cryogenic equipment. Use of ferrous materials has to be controlled to avoid interference with high magnetic-field equipment. These labs are often using high magnetic fields affecting neighboring labs and thus must be positioned carefully in the building and isolated to avoid disturbances.



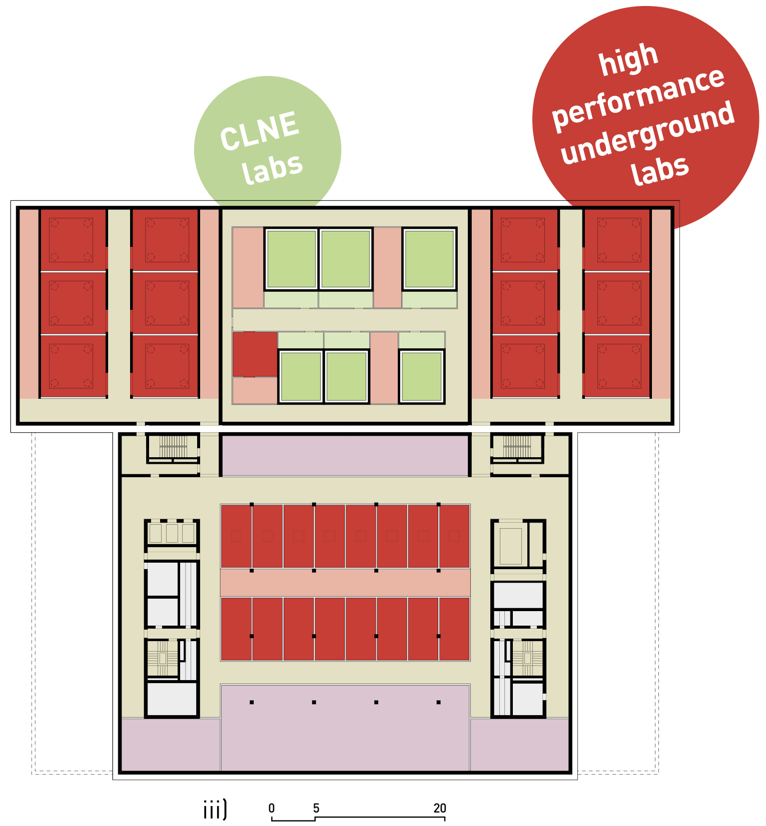
HPQ project, timeline and layout

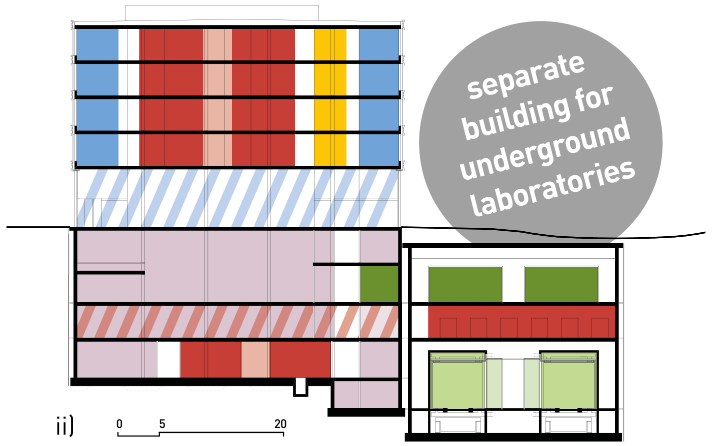
First ideas for this building go back to the year 2010, project planning will be finalized by the end of 2020 and construction will start in 2022. The building will start operation in 2028. This is a centennial project that will serve science, education, and technology for many decades to come. See timeline on the top right for further details. The three drawings show: i) one of the four above ground floors with offices at the periphery and laboratories in the interior, ii) a central cut across the HPQ building, with the view from the north towards the HIF building. Striped areas in light blue and red indicate offices and laboratories at the building periphery, iii) the third underground floor, with the main building holding the low temperature labs at the bottom and the laboratory building at the top. Shown are 12 high performance labs with plinths (left and right) and 6 CLNE labs in the center.





- FIRST II
- CLNE
- lab
- lab support
- office
- social
- circulation
- infrastructure





HPQ project, specifications

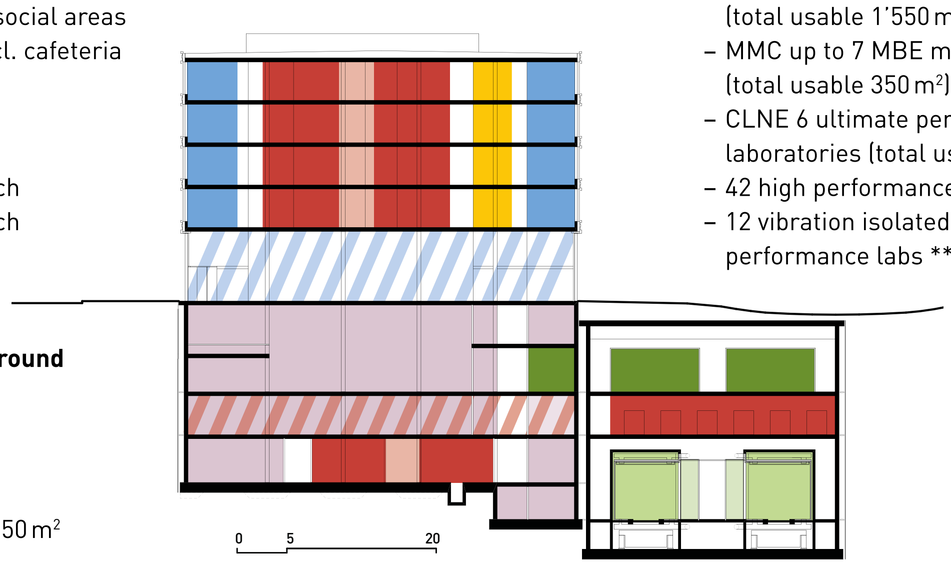
The project involves a main building and a specialized lab building. The main building hosts offices and generic lab space, as well as the infrastructure for both buildings to minimize disturbances in the lab building. The lab building hosts the three platforms (CLNE, FIRST II, MMC), as well as high performance labs.

Main building above ground
- volume 60'000 m³
- footprint 2'400 m² (60 m × 40 m)
- floor area 13'600 m²
- main usable area 7'600 m²
- 4 floors plus entrance and mezzanine
- 60 labs *
- 152 offices *
- meeting rooms and social areas
- conference space incl. cafeteria

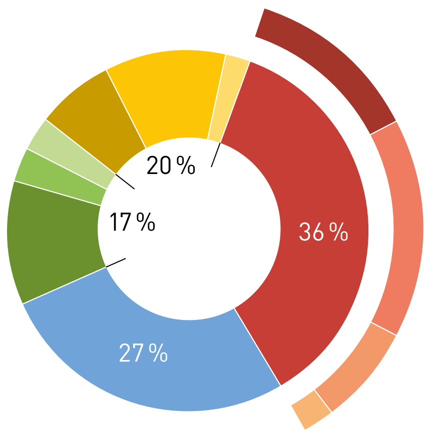
* in units of 25 m² each
** in units of 50 m² each

Main building below ground
- volume 50'000 m³
- footprint 2'880 m² (72 m × 40 m)
- floor area 11'250 m²
- main usable area 2'250 m²
- 4 floors
- 16 high performance labs *
- 10 vibration isolated high performance labs **
- technical infrastructure for complete HPQ

Lab building
- volume 40'000 m³
- footprint 1'900 m² (76 m × 25 m)
- floor area 7'750 m²
- main usable area 4'350 m²
- 4 floors
- FIRST II 14 cleanroom cabins (total usable 1'550 m²)
- MMC up to 7 MBE machines (total usable 350 m²)
- CLNE 6 ultimate performance laboratories (total usable 480 m²)
- 42 high performance labs *
- 12 vibration isolated high performance labs **



HPQ main usable areas



central circle, functional division of main usable area
outer segments, detailed division into different lab types

lab	5'150 m²	36 %
general	1'750 m²	12 %
optics	2'100 m²	15 %
low temp	1'050 m²	7 %
chem/prep	250 m²	2 %
office	3'800 m²	27 %
FIRST II	1'550 m²	11 %
MMC	350 m²	3 %
CLNE	480 m²	3 %
services	1020 m²	7 %
social	1550 m²	11 %
cafeteria	300 m²	2 %
total	14'200 m²	100 %

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