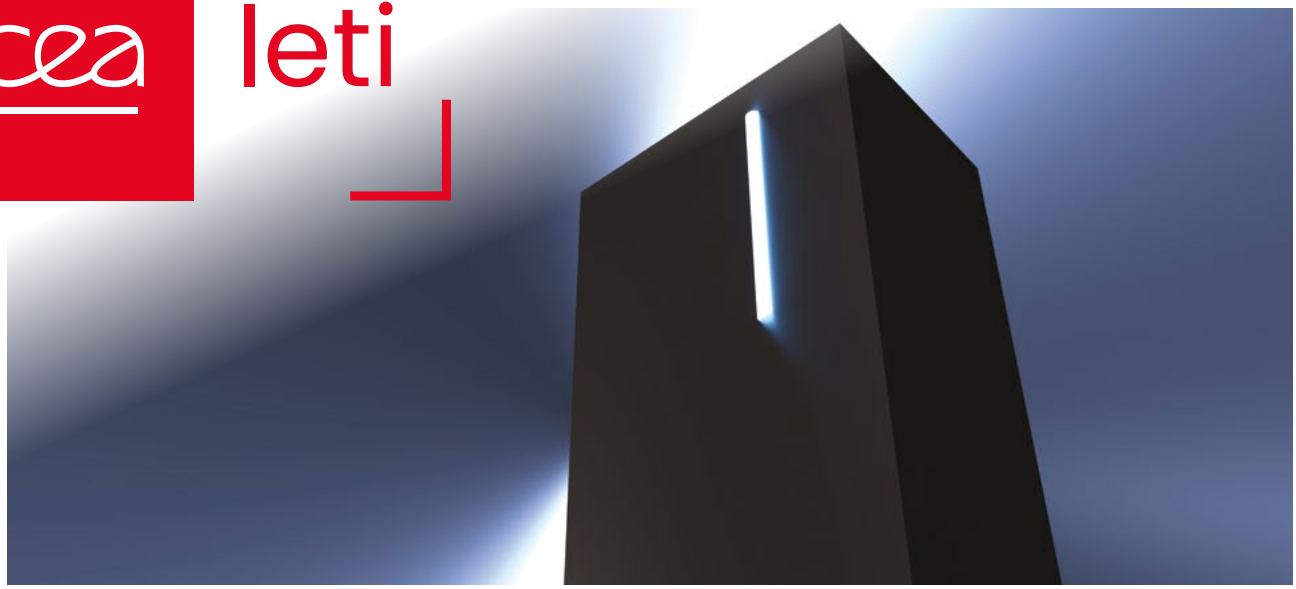
FRANÇAIS ENGLISH

cea leti



Quantum Computing

Towards large-scale quantum computers with silicon quantum bits

What is Quantum Computing?

Founded in 2018, the Quantum Silicon Grenoble consortium brings together CEA-Leti CEA-Irig, CNRS-Néel Institute, and UGA researchers, working towards the development of a 100-qubit processor. In an early success, the group encapsulated a single electron in a silicon circuit leveraging silicon-based CMOS technology. When this single electron reaches its quantum state, it is oriented towards the north and south magnetic poles at the same time. That is called a "*state superposition*". When a superposition is reached, a qubit takes simultaneously both 0 and 1 values, unlike conventional bits, which can only take one of these values at a time. This physical phenomenon helps boost computing capacity of quantum computers exponentially, compared to conventional computers.

Applications

The strength of quantum technology resides in the intrinsic parallelism of operations which, wisely used with specific algorithms, enables an exponential acceleration of computations, compared to current computers. Ultimately, quantum computing is likely to bring improvements within various areas, including:

- **Simulation**: i.e. helping to identify the best drug to eliminate viruses, bacteria or cure cancers; improving physics and materials science,
- **Machine learning and Big Data**: Developing autonomous vehicles, improving traffic, weather and financial forecasts, mathematical calculations, etc.,
- **Cybersecurity**: cryptography especially.

The choice of Silicon

There are four main ways to develop a quantum computer:
- Superconductors
- Photonics
- Trapped ions
- Electron spin within semiconductors (silicon)

The consortium has based its research on semiconducting based qubits because of its size, reliability, speed and operating temperature. Each member of the consortium brings the necessary skills and expertise for the development of a quantum computer:
- **CEA-Leti**: microelectronics manufacturing technologies, circuit and system design
- **CEA-Irig** (Interdisciplinary Research Institute of Grenoble): quantum properties of silicon-based nanostructures and measurements at very low temperatures
- **CNRS** (National Centre for Scientific Research) Néel Institute: quantum manipulation of individual objects
- **UGA** (Université Grenoble Alpes): quantum algorithms close to hardware

What's next?

The consortium developed the world's first silicon qubit with CMOS technology. The next major step will be the demonstration of a semiconductor quantum chip co-integrated with control and read-out electronics both based on semiconductor industry-compatible technology.

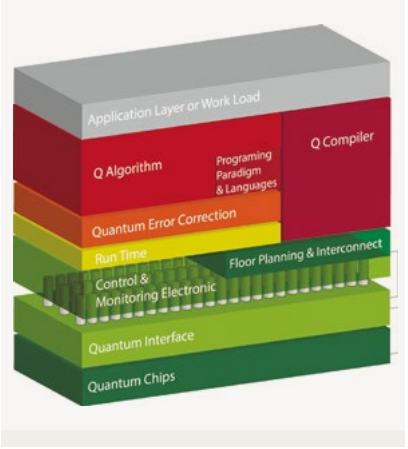
Many hurdles remain to be overcome. These include degrees of latitude, interactions, material quality and number of connections between qubits, addressing methods, measurement methods, decoherence, low-temperature control electronics, emission of control signals at room temperature, implementation of error-correcting codes, programming constraints, etc

Towards industrialization

CEA-Leti makes its clean room facilities and technological expertise available to academic or industrial partners exploring quantum technologies for industrialization. In particular, CEA-Leti is fully committed to supporting French quantum startups as with the start-up Quobly, from the CEA and the CNRS, dedicated to quantum computing and created on November 29, 2022 in Grenoble.

Key facts

- ERC Synergy, 2018, Tristan Meunier (Néel Institute, CNRS), Silvano de Franceschi (CEA-Irig), Maud Vinet (CEA-Leti).
- Leadership of the QLSI project within the Quantum Flagship. Goal is to deliver a demonstrator featuring 16 qubits in 2024.
- A dozen patents in a rapidly growing portfolio.



Interested in this technology?

Contact:
Vincent Barral
vincent.barral@cea.fr
+33 438 780 211

CEA-Leti, technology research institute
17 avenue des Martyrs, 38054 Grenoble Cedex 9, France
cea-leti.com

@CEA-Leti

Research for industrial innovation