
France conference Quantum
FRANCE QUANTUM 2025
Under the High Patronage of
Mr Emmanuel MACRON
President of the French Republic

SUMMARY:


France Quantum
CO-FOUNDED BY
OVHcloud
IBM Quantum
Pasqal
QUANDELA
quobly
QuRISK
Welinq
QUANTO NATION
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2025: the International Year of Quantum Science & Technology

How to Catch the Wave?

France Quantum returns for its 4th edition
June 10th, 2025 – Station F, Paris
Europe's largest quantum event is back, more ambitious than ever.

2025 has been proclaimed the International Year of Quantum Science and Technology by the United Nations, offering a unique momentum to accelerate innovation, foster collaboration, and scale impact globally.

Across Europe and internationally, the quantum ecosystem is rapidly evolving, with increasing engagement from industry players ready to transform promise into performance.

Join leading global stakeholders, explore concrete use cases, and discover how France and Europe are implementing bold strategies to position themselves at the forefront of thequantum revolution.

Don't miss your chance to catch the wave.
QUANTUM IS NOW.

"We need to build a strong quantum ecosystem in France and Europe, while encouraging key players to scale up their investments. The stakes are strategic, we must act now."

Damien Gromier, Founder and President, France Quantum

"France Quantum sets the stage for Europe's next quantum leap. As 2025 marks the UNESCO International Year of Quantum Science and Technology, it's time to catch the wave. At OVHcloud, we're committed to backing the ideas and collaborations shaping the future of quantum."

Fanny Bouton, Quantum Lead, OVHcloud and Co-Founder of France Quantum

"We are building a true sovereign ecosystem with our startups, corporate clients, and partners to create business opportunities. The message is clear: if you wait until everythingis ready, it will already be too late. The market will have already shifted, and your competitors will have taken action."

Octave Klaba, Founder & Chairman, OVHcloud

Following the success of the third edition of the France Quantum Conference — co-founded by OVHcloud, this book brings together insights from the 48 speakers who shared concrete use cases, visionary perspectives, and strategic outlooks on the future of quantumtechnologies in France and around the world.

Under the High Patronage of Mr Emmanuel MACRON President of the French Republic

The 2024 edition of France Quantum, held at Station F in Paris, brought together the quantum community under the theme **"Quantum for Industry: Why Now?".**
With over 750 participants, the event confirmed the increasing relevance of quantum technologies for industry and the growing maturity of the ecosystem, in France and across Europe.

Founded in 2020, France Quantum's mission is to foster the development and visibility of the French & European quantum ecosystem.
This pioneering initiative is led by **Damien Gromier** (Founder and President, France Quantum), **Fanny Bouton** (Fanny Bouton, Quantum Lead, OVHcloud), and **Octave Klaba** (Founder & Chairman, OVHcloud).

France Quantum is the first initiative within the French quantum ecosystem to bring together all key stakeholders (both public and private) around a shared ambition: to accelerate the adoption of quantum technologies, showcase impactful public-private collaborations and use cases across sectors, and strengthen the international visibility of the French and European ecosystem, with the ultimate goal of fostering the emergence of global champions.

The event has grown from its inaugural edition in 2022 at the Eiffel Tower, which welcomed 100 participants, to becoming **Europe's largest quantum event.**

2025, proclaimed by the United Nations as the International Year of Quantum Science and Technology, offers a unique global momentum to accelerate innovation, collaboration, and industrialization in quantum technologies.
France Quantum is proud to contribute to this collective ambition.

1.1 Honorary award:

France Quantum had the honour of presenting an award to **Eleni Diamanti** in recognition of her outstanding contributions to the field of quantum cryptography.

Eleni Diamanti is a CNRS Research Director at the LIP6 laboratory of Sorbonne University in Paris and Director of the Paris Centre for Quantum Technologies. With a strong background in electrical engineering, she received her PhD from Stanford University and has since become a leading figure in experimental quantum cryptography and communication. Eleni Diamanti's work focuses on the development of photonic resources for quantum networks and the design of secure communication networks using photons as information transmitters.

In addition to her academic role, she co-founded Welinq, a start-up dedicated to the development of quantum memories, crucial for long-distance quantum communication and the connection of quantum computing processors. Eleni Diamanti's contributions to the field have earned her several recognitions, including a European Research Council Starting Grant and the 2024 CNRS Silver Medal. She is actively involved in the French and European quantum ecosystem, collaborating with key industry and institutional partners, and bridging the gap between research and industry.

Dr. Diamanti and Dr. Grangier have collaborated closely since 2006, when she joined his lab as part of her Marie Curie Fellowship, focusing on quantum cryptography.

The award was presented by Philippe Grangier, Research Director at CNRS and a prominent expert in quantum optics and quantum information a the Institut d'Optique in Palaiseau.

He has authored over 200 publications and is internationally recognized for his contributions to quantum technologies, including single-photon experiments, atom-based qubits, and quantum cryptography.

"I have integrated the French Quantum ecosystem, I have been welcomed, and I feel it's the best place in the world to do quantum technologies today."

Eleni Diamanti, CNRS Research Director

1.2 Quantum Startup of the year 2024:

"We have succeeded in connecting a very good reliable technology to a community of users."

Valerian Giesz,
Cofounder & Chief Operating Officer,
Quandela

During the France Quantum Conference 2024, Quandela was awarded the Startup of the Year prize in recognition of its outstanding contributions to the advancement of quantum technologies. A pioneer in photonic quantum computing, Quandela is the first actor in the European Union to make its quantum computers publicly available on the cloud. The company collaborates with leading industrial stakeholders (including Crédit Agricole, EDF, and Thales) to co-develop use cases and accelerate the integration of quantum solutions into strategic sectors.

Receiving the award on behalf of the company, Valerian Giesz, Cofounder and Chief Operating Officer of Quandela, reaffirmed the transformative potential of quantum technologies. He described **the 21st century as the "quantum century" and highlighted France's key role in driving innovation and technological leadership in this field.** This recognition comes at a pivotal moment for Quandela, which recently secured €50 million in financing (the largest fundraising round in the quantum sector since France Quantum 2023) to support its international expansion and strengthen its industrial infrastructure.

In 2023, Quandela marked a significant milestone by delivering its MosaiQ quantum computer, powered by a photonic processor, to OVHcloud. This quantum computer, the first to be produced and deployed by Quandela, is now installed in an OVHcloud data center, making it the first to be hosted within a European cloud service provider. This collaboration demonstrates a strong commitment to building sovereign quantum capabilities and fostering the emergence of a competitive quantum ecosystem in Europe.

Chapter 1

Building Quantum Leadership: France and Europe's Strategic Vision

France is accelerating its leadership in quantum technologies through an ambitious national strategy and the broader France 2030 investment plan, designed to support scientific excellence, industrial innovation, and technological sovereignty.

1.1 France 2030: Quantum Technologies for Scientific and Industrial Leadership

Bruno Bonnell, General Secretary for Investment in charge of the France 2030 plan, emphasized during the conference the strategic importance of quantum technologies for France's scientific and industrial future. **In a rapidly evolving and increasingly complex world, he underscored the need to boost computational power to meet emerging challenges in artificial intelligence, energy efficiency, and advanced modeling.** Quantum technologies, with their capacity to handle a spectrum of possibilities beyond binary logic, are poised to become a foundational science of the 21st century.

France 2030, the national investment plan led by the French government, plays a central role in this ambition. With a budget of €54 billion, the program aims to accelerate industrial renewal, support cutting-edge technologies, and drive ecological transition. **Quantum, as a key domain for France's technological sovereignty and global competitiveness, has been designated as one of the three sectors of the "NewFrontiers" department alongside space and deep-sea exploration.** The State is committed to supporting both fundamental research and industrial development, helping to de-risk innovations and foster collaboration between public and private actors.

In just three years, the number of students enrolled in quantum-focused programs has grownby 30%. Landmark partnerships have emerged, such as PASQAL with Crédit Agricole CIB ; startups like Alice & Bob and Quandela are advancing through the stages of developing fault-tolerant quantum computers ; and **French companies now account for 20% of all quantum computers sold globally.** The recent deal between PASQAL and Aramco further illustrates the international recognition of French expertise.

He concluded by stressing the sovereign and security implications of quantum technologies. **The French defense procurement agency (Direction générale de l'armement - DGA) plans to acquire two quantum computers by 2030, reflecting national efforts to anticipate and manage emerging threats.** Bruno Bonnell reaffirmed the government's long-term commitment to quantum, closely linked with France's ambitions in AI, to ensure technological leadership and autonomy.

"No one in the general public truly understands the importance that quantum will have in the coming months, years, and probably centuries. [...] If we do not increase our computing power, France will fall behind in the scientific future of this world."

Bruno Bonnell, General Secretary for Investment in charge of the France 2030 plan

1.2 The French national quantum strategy

With €1 billion in public funding over five years, The French national quantum strategy launched in 2021, aims to support the entire quantum value chain, from research to industrialization. The strategy is structured around two major pillars: technological development and ecosystem structuring.

Six Technological priorities

A key component of the technological development is **the hybrid HPC quantum infrastructure, developed by CEA, INRIA and GENCI** with two main objectives:

1) **Integrate quantum processors directly into supercomputing centers.** Pasqal has delivered its first 100+ qubit quantum processing unit (QPU) to GENCI and CEA's TGCC (CEA's Very Large Computing Center) as part of the HQI program (France Hybrid HPC Quantum Initiative).

2) **Develop fault-tolerant quantum computers.** This effort is part of an R&D program led by CEA and INRIA in Grenoble. The objective of the program is to identify the key technological pillars that need to be addressed for different hardware providers to scale up the number of qubits. At the same time, the French Ministry of Defense through the PROQCIMA Program has selected 5 quantum hardware providers (Alice & Bob, C12, Pasqal, Quandela and Quobly) for a 15-year partnership to reach 100 logical qubits by the end of the decade, with intermediate milestones starting from two logical qubits within four years. anticipate and manage emerging threats. Bruno Bonnell reaffirmed the government's long-term commitment to quantum, closely linked with France's ambitions in AI, to ensure technological leadership and autonomy.

The four additional technological priorities are:

3/ Quantum sensors: In 2024, the government has granted seven consortia to develop newgenerations of quantum sensors.

4/ Post Quantum Cryptography: To anticipate future cybersecurity challenges, four consortia are currently working on the deployment of post-quantum cryptographic solutions to ensure resilience against quantum threats.

5/ Quantum communication: A dedicated testbed has been granted to support advancements in secure quantum communication networks.

6/ Enabling Technologies: Strategic investments are also made in quantum-enabling technologies. CNRS and CEA are leading a program focused on cryogenics, while the Institut d'Optique (IOGS), in collaboration with industry partners, is spearheading research around the next generation of lasers in partnership.

Three ecosystem priorities

1/ Basic Research: The government has granted 12 research projects across domains such as solid-state qubits, cold atoms, quantum algorithms, and communications. In parallel, France has seen a strong momentum in quantum research, with a 30% increase in scientific publications over the past three years, reflecting the growing vitality of its academic ecosystem.

2/ Qualified Workforce Development: To strengthen the quantum talent pipeline, the government supports QuanTEdu-France, a national initiative led by Université Grenoble Alpes. This program brings together a consortium of 21 universities across France, with the objective of significantly expanding educational offerings in quantum science and technology. As a result, the number of graduate students in the field has increased by 40%, and PhD enrolments have grown by 25%.

3/ Trustworthy standards: The National Laboratory of Metrology (LNE) is leading the METRIQS program to develop reliable metrics and benchmarks for quantum technologies. One of the flagship projects in this area is the BACQ project, led by Thales, which is focused on building an application-based benchmark for quantum computers. The goal is to evaluate the practical capabilities of quantum hardware based on real-world applications, rather than just the number of qubits.

Finally, Neil Abroug celebrated the vitality of the French quantum ecosystem. **France is now home to some of Europe's most dynamic startups, which have raised nearly €400 million in total.** These companies account for 20% of the global quantum hardware market and 15% of related job creation.

1.3 Europe strategy in Quantum Computing

Europe's Investment in Quantum Technologies

Europe is well-positioned in terms of public funding for quantum technologies, with major investments like the Quantum Flagship launched in 2018 (with nearly one billioneuros in funding) and strong contributions from member states such as France, Germany, and the Netherlands. Pascal Maillot, Deputy Head of Unit of Quantum Technologies at the European Commission, emphasized, **Europe has the advantage of a robust startup ecosystem and the excellence of its researchers.** However, this excellence also creates a paradox: while Europe is a recognized global hub for quantum science, it risks losing its top talent to better-funded and more agile markets like the United States. **While public funding is solid, Pascal Maillot pointed out quantum startups across Europe struggle to scale due to limited access to venture capital.** He noted the scarcity of venture capitalists specialized in quantum and the general hesitation of investors, which poses a significant challenge for scaling innovations. Moving forward, Pascal Maillot advocates for better harmonization of EU and member state budgets and stronger efforts to educate investors about quantum technologies to bridge the funding gap. He remains hopeful but acknowledges the challenge ahead.

Leveraging Public Procurement for Industrial Growth

Public procurement was widely recognized as a key lever for developing the European quantum industry. Rather than focusing solely on research subsidies, strategic purchasing by public institutions can accelerate the maturation of technologies and provide critical early revenue for startups. Thierry Botter, Executive Director of the European Quantum Industry Consortium (QuIC), stressed the importance of building a demand-side dynamic in parallel with technological supply. Flagship initiatives like EuroHPC, which is in the process of deploying six quantum computers across Europe, demonstrate the power of public procurement in stimulating the market. These machines, integrated into HPC infrastructures, will serve both as technological testbeds and platforms for user engagement, with access extended to researchers, developers, and students. Similarly, the European Quantum Communication Infrastructure (EuroQCI) initiative aims to establish a secure quantum communication infrastructure, further solidifying Europe's strategic autonomy.

Strengthening Coordination Across Member StatesGrowth

A better alignment between European and national initiatives is a central challenge. While the EU provides a unifying framework, member states often pursue parallel agendas, leading to fragmentation and inefficiencies. Pascal Maillot underlined the importance of synchronizing timelines, funding instruments, and strategic objectives to avoid duplication of effort. A more coherent and collaborative governance model would maximize impact and accelerate industrial deployment. Networks such as QuIC (the European Quantum Industry Consortium) already play a key role in fostering cross-border cooperation among companies, but more formal mechanisms are needed to ensure long-term alignment. Thierry Botter pointed out that while the quantum industry is still early in its development, the groundwork for future consolidation is being laid. **Building a clear picture of the ecosystem is essential.** With nearly 200 members, QuIC provides a platform where nearly 200 members from across Europe (ranging from core quantum startups to potential end users) can meet, exchange, and explore collaboration opportunities. This is a foundational step toward eventual consolidation, which could occur through mergers or equity positions. Similarly, Liran Naaman, Program Manager at Quantum Delta NL, stresses the importance of engaging companies early to demonstrate real-world impact and attract investment.

Growing Engagement of End Users

A major evolution underway in the quantum ecosystem is the increasing engagement of end users. Thierry Botter highlighted that companies in sectors such as aerospace, automotive, and pharmaceuticals are beginning to explore how quantum technologies could transform their industries, starting today. **While computing remains a strong focal point, sensing and communication are rapidly gaining traction due to their shorter deployment timelines.** Sensors, in particular, are already being deployed in real-world environments, prompting industrial players to evaluate their near-term impact. A notable example is the joint initiative between Airbus and BMW, illustrating how **leaders from different industries are exploring the practical applications of quantum computing to address sector-specific challenges.**

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Pascal Maillot added that quantum sensing, once rooted in basic research, is now advancing toward tangible deployment. Europe is investing in projects such as a continent-wide network of quantum gravimeters and is actively exploring ways to scale up sensor development. **These technologies have moved beyond laboratory settings and are increasingly ready for real-world use. Crucially, quantum sensors are dual-use, with both civilian and defense applications, positioning them as a strategic priority.** As Pascal Maillot pointed out, fostering a new generation of European champions in quantum sensing will be essential to ensuring Europe maintains leadership across all pillars of quantum technology. This convergence of end-user engagement and sensor readiness signals a shift: quantum is no longer a speculative future, but an actionable strategic tool for industry today.

From Scientific Leadership to Strategic Sovereignty

Europe must now move beyond scientific leadership to become a strategic actor in the global quantum industry. This means creating markets, mobilizing private investment, aligning national and EU policies, and engaging end users. As Thierry Botter noted, the challenge is no longer just advancing research, but asserting Europe's technological sovereignty in a field that will shape the future of digital power.

"In Europe we are very well placed in terms of Public Funding [...] but the big fight is with private funding."

Pascal Maillot, Deputy Head of Unit of Quantum Technologies, European Commission

"It's important to highlight the strong engagement that has taken place across Europe for Quantum Technologies, governments very early on put forward funds and programs in support of quantum."

Thierry Botter, Executive Director, European Quantum Industry Consortium (QuIC)

Chapter 2

Translating Quantum Vision into Technological Action

2.1 - Accelerating the quantum error correction era

Chloé Poisbeau, COO of Alice & Bob, and **Rebecca Simmons,** COO of Riverlane, share a common objective: bringing fault-tolerant quantum computing to reality. While their companies focus on different aspects of the quantum stack, their collaboration is essential to accelerating progress toward practical quantum computers.

Founded in 2020, Alice & Bob is developing a fault-tolerant quantum computer based on cat qubits, a unique qubit architecture that provides built-in protection against bit-flip errors. While quantum errors typically fall into two categories: bit-flips and phase-flips, **cat qubits inherently correct bit-flips, leaving only phase-flips to be managed externally.** This approach drastically reduces the number of physical qubits needed to construct a logical qubit: just 15 cat qubits, compared to thousands using conventional methods. This compactness significantly accelerates scalability. **Their goal over the next two years is to demonstrate fault tolerance with a 40 cat chip.** Once this milestone is achieved, scaling up will pave the way for a fully operational quantum computer. **Currently, they are working on Helium 1, a 16-cat-qubit chip that is in the calibration phase.** This first step aims to validate their ability to correct errors.

While Alice & Bob is pioneering a quantum computing system based on cat qubit technology, Riverlane is building the quantum error correction (QEC) stack needed to make it practical. Their solution is Deltaflow, a suite of tools designed to help quantum companies build and operate fault-tolerant quantum computers. This is a powerful classical co-processor leveraging proprietary decoding algorithms and capable of processing terabytes of data to correct quantum errors on the fly, essential for achieving fault tolerance.

Deltaflow is designed to be qubit-agnostic and energy-efficient (using only 8 mW), and it fits into a chip smaller than a grain of rice. The roadmap evolves from basic error correction (Deltaflow One) to universal fault-tolerant operations (Deltaflow Mega) over the coming years.

By combining Alice & Bob's quantum computer with Riverlane's cutting-edge error correction technology, the two companies are laying the groundwork for a fully operational fault-tolerant quantum computer.

"At Alice & Bob, we are focusing on fault tolerance, so error correction. Cat qubits have a strong advantage on error correction. (...) The cat qubit is autocorrecting the bit flip so we only need to focus on the face flip error"

Chloé Poisbeau, COO, Alice & Bob

2.2 - Exploring the Implications and Applications of MPQP in the Context of Photonic Quantum Computers

Laurent Guiraud, co-founder and quantum computing R&D lead at ColibriTD, and Jean Senellart, CPO at Quandela, share a common goal: making quantum computing accessible to everyone. They introduced the concept of MPQP (Multi Platform Quantum Programming), an innovative library developed by ColibriTD, aimed at simplifying access to and usage of quantum technologies.

With over 70 hardware providers emerging, a generic and flexible solution was necessary to offer interoperability between different quantum platforms through a unified API. Developers no longer need to relearn various SDKs specific to each quantum provider, significantly reducing development time and paving the way for faster innovations. Initially built for internal use, MPQP soon proved its value, leading the team to release it as open-source.

By enabling developers to program an algorithm only once and run it across various platforms, MPQP eliminates technical barriers and makes quantum computing accessible to a broader audience.

Laurent Guiraud and Jean Senellart highlighted that real-world experimentation must begin now, even with today's limited number of qubits, with the goal of demonstrating scalability. MPQP is already being used to simulate complex physical systems such as 1D flame combustion, fluid dynamics, and material deformation. These applications may not yet outperform classical methods, but they provide valuable insight into scalability and noise modeling, key steps in proving future quantum advantage.

Among the various quantum computing approaches, photons offer several advantages, including predictable quantum noise that simplifies output analysis. They also operate in Fock space, which is larger than the traditional Hilbert space, allowing for more exploration with a relatively small number of photons.

The discussion also pointed to the strategic importance of partnerships. For example, the recent acquisition of a photonic quantum computer by OVHcloud provides immediate access to real quantum hardware, enabling real-time testing. MPQP's ease of use (it can be installed and running on notebooks in minutes) makes it an ideal tool for industrial players looking to evaluate quantum-readiness in their specific domains, particularly in optimization problems, which remain a widespread challenge across sectors.

The overarching message is clear: start testing now. There is no need to wait for millions of perfect qubits. As with previous technological shifts, from cloud to AI, those who engage early will help shape the ecosystem and be best positioned to lead in the quantum era.

"As of today, what is important is that you can test. What's useful is that it's available now. If you can use a computer today with 10 photons, then of course it's more useful than using any other technology with 5,000 qubits that will only be available in 10 years."

Jean Senellart, Chief Product Officer, Quandela

"80% of our work is research, but we are not labs. The end goal is to work with industrial partners, to deliver solutions at scale."

Laurent Guiraud, CEO and Co-founder, ColibriTD

2.3 - Achieving Quantum Advantage with Neutral Atoms

Loïc Henriet, Co-CEO of Pasqal, presented Pasqal's vision and progress toward achieving quantum advantage using their proprietary neutral atom technology.

Pasqal has successfully transitioned from academic prototypes to industrial-grade quantum processors. Their Orion Alpha system is already being used on real-world use cases such as: Toxicity screening from molecular structure, protein hydration for drug discovery, 5G frequency assignment problem, quantum magnet dynamic, optimization algorithm, credit risk analysis, smart charging of electric vehicles, differential equation solving, mission planning for satellites. These use cases rely on stable devices, delivering reproducible results, and offer strong uptime. **Orion Alpha demonstrated over 90% uptime in March–April, an unprecedented figure for systems based on atomic physics, traditionally prone to manual intervention and instability.**

Quantum Advantage with Neutral Atoms

Loïc Henriet emphasized the importance of **building a collaborative ecosystem:**

- With HPC centers for hybrid workflows combining classical and quantum computing
- With startups and academic institutions for co-developing software and control systems
- Through open-source contributions, including tools like Pulser and Cadence, and upcoming algorithmic toolkits ("Quantum routines")

Pasqal is also investing in education and awareness, with initiatives like Quantum Discovery, an e-learning and use case exploration platform that will expand further in 2025.

A major announcement came with the first commercial sale of a neutral atom quantum processor: a 200-qubit Orion device to Aramco (Saudi Arabia), to be deployed in 2025. Initially designed for analog workloads, the system will be upgradable to a hybrid analog-digital mode, marking a pivotal moment for industrial adoption. **multicore quantum computing.**

Loïc Henriet identified two primary application domains for neutral atom processors:

- **Quantum Matter** - describing the behavior of quantum systems at the microscopic scale, enabling the exploration of complex phenomena such as low-temperature magnetic dynamics, which remain out of reach for classical high-performance computing.
- **Quantum AI** - Pasqal showcased a hybrid classical quantum approach to graph-based toxicity prediction for molecules. Their solution integrated quantum-encoded aggregation layers into state-of-the-art graph neural networks, outperforming standard GPU-based methods.

Looking ahead, Pasqal is targeting aggressive scaling along **three key hardware axes**:

- **Number of qubits** (with a recent demonstration of >1,100 atoms trapped in a single shot)
- **Qubit addressability** (more granular control over operations)
- **Repetition rate** (faster result acquisition)

In the long term, Pasqal plans to tackle quantum error correction and develop interconnected QPUs to enable scalable, multicore quantum computing.

"That was a real challenge for us: te really take the technology that was developed in academic labs [...] and really turned it into a product that can be deployed on premise and put on the cloud"

Loïc Henriet, Co-CEO, Pasqal

2.4 - Scaling quantum computing using carbon nanotube-based qubits

At the core of C12's vision is a unique approach: building large scale fault-tolerant quantum computers using carbon nanotube-based qubits. Pierre Desjardins, co-founder and CEO of C12 outlined how C12's qubits benefit from both exceptional isolation from environmental noise and compatibility with existing silicon-based chip manufacturing, enabling high fidelity and scalability. These properties are particularly promising for applications such as quantum chemistry, which demands both qubit stability and precision. **C12 is currently the only startup globally pursuing this technology path,** which originated from fundamental research at the École Normale Supérieure in Paris. The ability to integrate carbon nanotubes on silicon substrates allows for a semiconductor-style fabrication process, supporting the industrial scalability of the platform.

Pluton Pullumbi, Air Liquide International Fellow, explained **Air Liquide's dual role in the quantum ecosystem:** firstly, as a key supplier of cryogenic cooling systems for quantum machines; and secondly, as a potential end user of quantum computing. Air Liquide provides precursors (Organometallic complexes essential to semiconductor manufacturing to make chips) and gas management systems to control molecular reactions on surfaces. As the semiconductor industry evolves rapidly, optimizing and adapting precursors to new needs becomes essential, something not feasible through experiments alone. To address this, Air Liquide has long relied on classical computational chemistry (ab initio) for virtual screening. However, these methods struggle to accurately model transition states, which are key to understanding surface reactions. This led to the central question: **can quantum computing predict energy barriers with chemical accuracy (around 1 kcal/mol)?**

To address this, Air Liquide partnered with C12 and quantum algorithm specialist Quantinuum, to evaluate quantum computing's potential to deliver "chemical accuracy" for modeling reaction barriers.

The project involved a **hybrid quantum-classical workflow: classical methods determined molecular geometries, while quantum algorithms focused on the active space,** the most entangled regions of the reaction. C12's Kalisto emulator (hosted on OVHcloud), a high-fidelity digital twin of their quantum processor, was used to test these algorithms.

The team tested simplified molecular models and demonstrated algorithmic convergence matching classical results. However, scaling to larger systems would require 50–60 high-quality qubits, highlighting the need for further improvements in hardware error rates and more robust quantum algorithms.

While early results are promising, both Pierre Desjardins and Pluton Pullumbi stressed that we are still in a transitional phase. Quantum computing can already offer advantages in reduced active spaces, but full-scale industrial impact will require further advances in error mitigation, algorithm design, and qubit quality.

"Air Liquide has a double interest in quantum computing. First, the cryostats and the cryogenic and cooling. Second, is how we use quantum computing to improve our processes and our offer for our clients."

***Pluton Pullumbi**, Air Liquide International Fellow*

"We are the only startup in the world to develop this kind of technology [...] Carbon nanotubes can make very high-quality qubits. It's an incredible material that protects the qubit from noise."

***Pierre Desjardins,** Co-founder & CEO, C12*

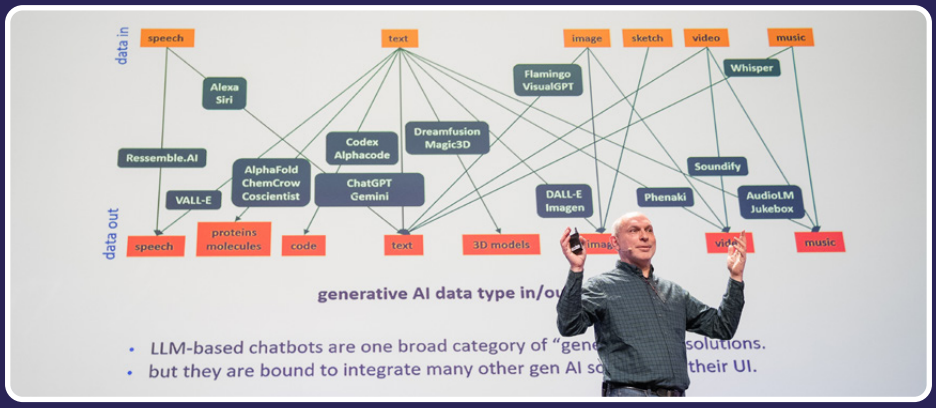
2.5 - Unlocking synergies between AI, LLMs, and quantum sciencebased qubits

Olivier Ezratty, author of Understanding Quantum Technologies, explained how AI, and especially LLMs, can accelerate progress in quantum research, supported by real-world experiments and use cases. Machine Learning (ML) is already embedded in many aspects of quantum research like:

- Quantum error mitigation
- Optimizing qubit frequency allocations
- Identification of topological materials
- QEC error syndrome detection
- Driving qubit control electronics
- Qubit gate synthesis
- Correcting quantum sensor noise

Initially skeptical about LLMs (due to their tendency to “hallucinate” or oversimplify complex content) Olivier Ezratty shifted his view after extensive testing with experts like Philippe Grangier, to explore their utility in quantum research.

He classifies Large Language Models (LLMs) as a key component of Generative AI (GenAI), a broad category of AI systems designed not just to understand input, but to create new content. This content can range from text (like explanations or reports), to computer code, molecular structures, mathematical expressions, images, and even proteins or quantum circuit diagrams.



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What makes these models powerful isn’t just their ability to guess the next word in a sentence. They go far beyond simple word prediction by incorporating reasoning capabilities, chain-of-thought logic, and tool use, like plug-ins or APIs. This combination of generative abilities, reasoning, and interactive tool use is what allows LLMs to function as emerging scientific co-pilots. **They support researchers by helping them write code, explain theories, test ideas, and even suggest experimental methods, all in real time and across different scientific domains.**

Ezratty outlines a structured approach for effectively utilizing AI tools in quantum research: first, defining the user’s profile to guide model responses; second, mastering prompt engineering; and third, rigorously fact-checking results as LLMs can still hallucinate or misrepresent complex, nuanced topics.

Current use cases of LLMs in quantum science are expanding. They include:

- Providing foundational knowledge on quantum science.
- Assisting with figures of merit, such as photon sources, detectors, circulators, and TWPAs.
- Creating inventories of materials and research avenues.
- Performing simple math and logic operations.
- Offering bibliographic assistance.
- Generating and analyzing code (Phython for creating charts, PHP, regex, VBA…)
- Drafting non-scientific memos (policy making, quantum winter…)

While models can perform surprisingly well in algorithm design benchmarking, they still struggle with tasks like creating schemas, analysing charts in scientific papers, summarizing scientific papers, finding missing figures of merit in papers, bibliographies, reasoning, or data consolidation.

Olivier Ezratty also shared his vision for how LLMs and AI tools might help researchers and students become more creative and productive. He envisioned systems that could support hypothesis testing, identify gaps in the literature, propose new research directions, or bridge knowledge across multiple scientific fields, particularly important in interdisciplinary areas like quantum computing, which combines hardware, algorithms, physics, and software engineering.

However, he also highlighted barriers to adoption, especially in Europe. **Many researchers in startups or institutions are prohibited from using tools like ChatGPT due to privacy concerns, GDPR issues, or fears of leaking proprietary data to U.S.-based servers. This creates a competitive disadvantage**. One solution, he suggested, is building domain-specific AI assistants using open-source models like Mistral, paired with secure architectures and scientific datasets. Building such systems, though, is non-trivial: it requires expertise in LLMs, data curation, software engineering, UI design, and scientific understanding. He argued for more cross-disciplinary collaboration between the AI and quantum communities to accelerate progress.

Chapter 3

Unlocking Quantum Value: Industry Use Cases and Strategic Readiness

3.1 Decoding the quantum landscape and be prepared for Commercial Quantum Advantage

"We still need a lot of investment from the government. For context, we're looking at currently around a 36 billion dollar spend globally, going up to 42 billion in the coming years"

Tahmid Quddus Islam, Assistant Vice President of Innovation & Technology, CITI Global Insights

Tahmid Quddus Islam, Assistant Vice President of Innovation & Technology at CITI Global Insights, poses a fundamental question: what would it mean for us to truly understand the quantum computing landscape? To answer this, he conducted extensive interviews with over 100 world-leading experts, ranging from Nobel laureates, regulators and government officials to CEOs of quantum computing companies and he came to the following conclusions:

1) Government Investment: Significant government investments are required to achieve commercial quantum advantage, which means outperforming classical computers in useful tasks. Government budget commitments are estimated at $36 billion in 2023 and will reach $42 billion by 2027.
Today, investment levels vary widely between nations. France, the USA, the UK and Germany make significant expenditures ranging from 1 to 4 billion dollars. China is still undecided between investing $4 billion or $17 billion. This clearly reflects the current state of the quantum industry: governments remain uncertain about its future economic impact.

2) Workforce Education: Beyond financial investment, the development of a skilled workforce is another critical factor in advancing quantum computing. Although short courses are available to enable upskilling, a talent shortage remains a significant barrier to growth. National security concerns limit access to foreign talent.

3) Market Opportunity: Governments and companies invest to capitalize on this market opportunity. The average Total Addressable Market (TAM) was $650m in 2022 for an estimated $2.1bn in 2027. But there is a massive divergence in these forecasts, up to tenfold.

4) Value Creation: Growth will likely be characterized by multiple inflection points. Inflection points are based on each era of commercial quantum advantage (Machine Learning, materials, faster and better optimization, chemistry …). The nature of commercial quantum advantage will be highly granular. The creation of value estimated at around $450 to $850 billion over the next 15 to 30 years will be categorized under these four areas of commercial quantum advantage: Machine Learning, Optimization, Simulation, and Cryptography.

5) Collaboration and The Cloud: Collaboration is needed to bring about sufficient standards. Standardization is necessary to provide a smoother experience for businesses. The cloud plays a key role by simplifying access and reducing the high infrastructure and maintenance costs.

How to prepare for Commercial Quantum Advantage?

Three general stages:

- **Quantum Awareness:** Address common misconceptions, and evaluate the strengths and weaknesses of quantum computing.
- **Quantum Preparedness:** Create a skills map of individuals within our organization to identify a point person or working groups. This will help us understand the risks and opportunities quantum computing presents, build internal quantum expertise, and identify potential quantum partners to plan the integration of quantum technologies.
- **Quantum Advantage:** Integrating quantum technologies is challenging and requires proof of concept, as they involve new mathematics and are not plug-and-play like AI. Most algorithms will not be well-suited for quantum computers, so integration into existing workflows and cost strategies will vary greatly depending on the level of quantum access desired.

3.2 Strategy and Adoption of Quantum Computing

Julian Van Velzen, Head of Capgemini's Quantum Lab, and his team are working on full system integration, building complete workflows for quantum chemistry and other areas of quantum tech. In partnership with IBM, they have achieved remarkable progress. During a dedicated session, **Scott Crowder,** Vice President of IBM Quantum, recalled a significant milestone in recent history: in 2016, IBM became the first company to make quantum computers accessible via the cloud, allowing researchers and engineers to explore the potential of quantum computing. Since then, progress has been exponential. In 2023, IBM demonstrated a system exceeding 1,100 qubits while also advancing software capabilities, making it possible to run quantum circuits that produce useful results beyond what classical computers can achieve. This rapid progress has been driven by breakthroughs in two key areas:

- Demonstrating the utility of quantum computers, which opens the door to real-world industrial applications.
- Enhancing error correction, with a new LBDC code that is ten times more efficient than the Surface Code.

IBM plans to have a system capable of running over 100 million gate operations by 2029 and a system exceeding one billion gate operations by 2033. This evolution is reshaping their approach, their collaboration with industries, and how businesses perceive the technology.

Despite these achievements, there are still significant hurdles to overcome in fully harnessing quantum computing's potential. Julian Van Velzen acknowledges these advancements but highlights three major challenges that remain:

- **Improving hardware:** Especially for applications like quantum chemistry, the required computational scale is still beyond current capabilities.
- **Integrating quantum computing into existing workflows:** It's complex to combine quantum algorithms with classical computing environments, and embedding technologies still require further development.
- **Assessing costs and the right time to invest:** Quantum computing will be expensive. Companies must identify timely, high-value use cases to justify the investment.

Scott Crowder agrees with this assessment and notes a fundamental shift in how companies approach quantum technology.
When IBM launched its Quantum Acceleration Program five years ago, efforts focused on skill development and education. Today, the emphasis is on prototyping, utility-scale work, and leveraging it as a practical computational tool.

"We put the first real quantum computers on the cloud back in 2016. (...) At the time, it was really to give a chance to explore using real quantum computing. Also, to help people who are doing deep quantum information science research to do research on quantum computing"

Scott Crowder, Vice President, IBM Quantum

Julian Van Velzen emphasizes the importance of moving beyond general knowledge toward targeted applications. Shifting Mindsets: From Research to Real Use Cases.

- There is a growing shift from using quantum computers to study quantum systems toward using them as practical computational tools.
- Organizations are becoming more specific in their exploration — for example, not just "drug discovery" in general, but targeting specific molecules and concrete problems.

"Quantum computers won't be cheap to use, so we have to be really carefully thinking about where it actually makes sense to use them, and in what time frame."

Julian Van Velzen, Head of Capgemini's Quantum Lab, Capgemini

Julian Van Velzen outlines strategic advice for companies. The journey should begin with education and awareness by forming a core champion team, exploring partnerships, and building internal communities.
Then, companies that are already exploring quantum technologies should:

- Focusing on concrete use cases (e.g., specific molecules, circuits, and observables)
- Assessing how quantum fits into end-to-end workflows
- Evaluating commercial viability, not just theoretical advantage

3.3 Quantum for Defense & Space

Patrick Aufort, Director of the Defence Innovation Agency (AID), emphasized the transformative impact of the Military Programming Law (LPM) in shaping France's defense innovation strategy. This law ensures long-term funding and sets clear goals to stay ahead in technology. The latest iteration, passed in summer 2023, allocates 10 billion euros to innovation from 2024 to 2030. Despite this significant investment, AID must prioritize resources carefully. There are ten main priority technologies in the investment strategy. Among them: quantum computing, sensors, artificial intelligence, drones, robotics, hypersonic velocity, new energy solutions, and communication technologies.

Quantum technology is a game-changer, with uses such as ultra-sensitive sensors and secure communication. A major change in the new LPM is the return of large-scale test projects, which had stopped for ten years due to funding issues. These projects accelerate the transition from laboratory research to practical application. A key example is the **GIRAFE 2** atomic gravimeter, a quantum sensor for defense applications.

AID supports the French quantum ecosystem and makes strategic investments in quantum computing through the **PROQCIMA program,** designed to accelerate France's capabilities in this field. The program collaborates with leading French quantum companies, including Quandela, C12, Pasqal, Alice & Bob, and Quobly. It follows a structured roadmap:

1. Evaluate technologies from these five selected companies.
2. Select three companies for prototype development.
3. Develop a 128-qubit prototype within four years.
4. Down-select two companies for long-term scalability and deployment.

As quantum capabilities mature, secure communication has become a critical focus for defense and cybersecurity. **Kasia Balakier,** Optical & Quantum Communication Technology Manager, leads the agency's efforts in this domain. The European Space Agency (ESA) is actively developing five quantum communication missions, primarily centered on Quantum Key Distribution (QKD). One key initiative is the development of portable ground stations, recognizing the vital role of satellites in enabling secure quantum communication where fiber-optic networks are impractical. Simultaneously, ESA is exploring quantum information networks that integrate sensors for military and civilian applications.

Satellite-based quantum communication addresses the need for security, directly tied to advancements in quantum cryptography. Kasia Balakier highlights two primary satellite-based QKD protocols:

- **Direct QKD Transmission:** A satellite sends quantum keys to two separate ground stations, establishing a secure communication link.
- **Entangled Photon Distribution:** A satellite generates and simultaneously delivers entangled quantum keys to both ground stations, ensuring highly secure encryption.

Higher satellite orbits provide broader coverage, reducing dependence on fixed installations, while mobile ground stations enhance flexibility for secure long-distance communication.

The success of quantum technologies hinges on collaboration between governments, industry, and academia. Kasia Balakier cites the **Scylight program** as a model for public-private partnerships, bringing together 11 partners from large industries, SMEs, and research institutions in advancing quantum security. Another key public-private partnership, **Eagle One,** serves as a precursor for operational QKD deployment. These initiatives align with Europe's broader strategy to achieve technological sovereignty in quantum security.

Patrick Aufort underscores a clear reality: quantum technology is no longer a distant vision; it is an operational asset. The next step is to advance both hardware and software in parallel, ensuring that quantum computers reach their full potential.

"Quantum sensors are not an equipment of the future. We are not on the point to deliver, we have already delivered; not demonstrators but equipment"

Patrick Aufort, Director, Agence de l'Innovation de Défense

3.4 Quantum Computing in the Insurance Sector

Quantum computing is believed to have the potential to significantly transform the insurance industry. According to **Sébastien Marie,** Chief Technology and Information Officer at Matmut, quantum technologies can be applied to a wide range of use cases within the insurance sector.
At Matmut, the main quantum use cases currently being explored include:

- Risk assessment and modeling
- Portfolio optimization
- Fraud detection
- Predictive modeling
- Pricing model optimization, with a particular emphasis on improving the C/C ratio (combined cost ratio), a key performance indicator in the insurance industry.

Matmut is collaborating with **QbitSoft,** a French startup founded in 2022 that specializes in developing quantum optimization algorithms on the cloud platforms to support a variety of business use cases, as **Olivier Pegeon,** Co-founder and CEO of QbitSoft, explained.

According to Olivier Pegeon, collaboration with startups is essential. Large businesses often hesitate to invest heavily in R&D, while startups like QbitSoft are well-positioned to identify short- and medium-term opportunities where quantum computing can already create tangible value.

Both Matmut and QbitSoft agree that two key challenges must be addressed to successfully integrate quantum technologies into the insurance industry. The first is convincing executive boards that quantum computing is no longer science fiction, but a viable tool for experimentation and innovation today. The second is training internal teams to develop the skills necessary to work with quantum technologies.

In this collaboration, QbitSoft is supporting Matmut by contributing to the mathematical formalism and helping select the most appropriate hardware, and coding the solution using the right quantum frameworks. On the other hand, Matmut is actively contributing to QbitSoft's research and development activities. This partnership allows QbitSoft to learn from a real-world application, refine its technologies, and better understand how to generate value in operational contexts.

Beyond pricing models, the two partners are also working together on a new quantum project focused on fraud detection, which is co-funded by the Île-de-France Region.

"A partnership is necessary to help our teams understand our quantum physics, the quantum principles that can help us solve complex problems"

"The right time to begin with quantum computing was two years ago; the second right time is now. Let's go."

Sébastien Marie, Chief Technology and Information Officer, Matmut

"The easiest way to start exploring quantum is to work with a startup. (...) We have the skills to understand where you are in terms of maturity, we can help select the right switch spots to get value, and we adapt very quickly to the client situation"

Olivier Pegeon, Co-founder & CEO, QbitSoft

3.4 Quantum Computing in the Insurance Sector

Quantum for Aerospace

Airbus has been exploring quantum technology for the past decade, identifying its relevance in the aerospace sector early on.

Isabell Gradert, VP Central Research & Technology, explained the main use cases:

- **Quantum Sensing:** with precision navigation in GPS-denied environments
- **Quantum Communication:** Secure and resilient communication channels, critical for aircraft systems and global infrastructure.
- **Quantum Computing:** Applied to high-performance simulations, optimization problems, and complex design challenges.

The company has identified four major clusters of quantum use cases:

- **Quantum Simulation:** Airbus is leveraging quantum computing to discover new materials or optimize the properties of existing ones, such as corrosion modeling.
- **Quantum Optimization:** Addressing combinatorial problems related to flight scheduling, trajectory planning, and supply chain logistics.
- **Quantum Machine Learning:** Exploring advanced data processing capabilities for predictive maintenance and operational efficiencies.
- **Quantum Solvers:** Enhancing complex equation-solving capabilities, particularly in aerodynamic and aeroacoustic modeling.

A key focus for Airbus is how quantum computing can contribute to the aviation industry's decarbonization efforts. For example, Airbus explored quantum computing to improve hydrogen fuel cell efficiency for aircraft and partnered with BMW and Quantinuum to study chemical reactions to improve performance and aid aviation decarbonization.

Quantum for Material Science and Optimization: BASF

BASF is deeply invested in quantum computing, with half of its quantum team dedicated to materials and molecular use cases development, and the other half focused on optimization and quantum machine learning exploration. The company is particularly interested in quantum computing's ability to predict chemical reactions by finding the ground state of molecules, a crucial aspect of chemical and material innovation.

As **Michael Kaicher,** Quantum Scientist at BASF, points out, adopting quantum technology is a gradual process that requires continuous development and understanding. The company is actively engaged in research collaborations and partnerships to drive innovation in the field.

Quantum in Railway Systems: SNCF

SNCF, the French railway operator, entered the quantum computing space five years ago, recognizing the importance of technological anticipation in an industry where infrastructure and operations are designed for long-term use. SNCF's primary quantum focus has been on combinatorial optimization problems, such as:

- **Early-stage railway operation planning:** determining the most efficient set of trains to operate
- **Real-time management of disruptions:** Dynamically reordering trains to optimize customer satisfaction and asset management.

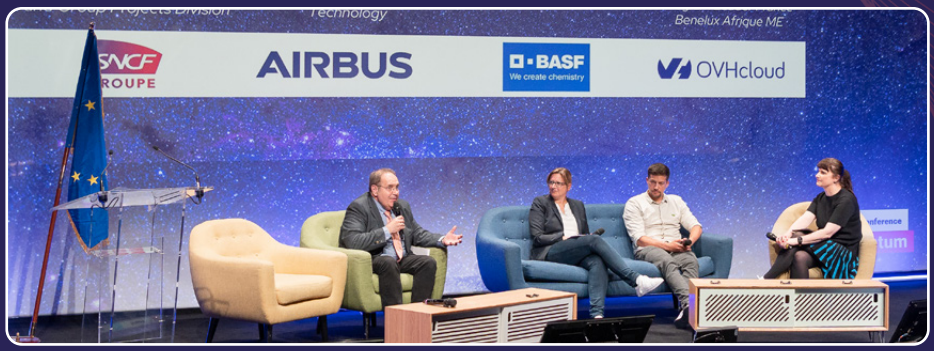
David de Almeida, Head of Science and Research in SNCF's Technology, Innovation and Group Projects Division of SNCF affirmed that, by integrating quantum computing, SNCF aims to reduce computation time for these complex problems, ultimately improving operational efficiency.

"Quantum technology is really seen as one of the big disruptors in Aerospace, and it really has the potential to create a massive paradigm shift in the way aircraft are flown"

Isabell Gradert, VP Central Research & Technology, Airbus

"We are part of some communities. It's very valuable for us so that we can share some experiences about use cases (...) and provide some ways to access some facilities to test our quantum models"

David de Almeida, Head of science and Research in SNCF's Technology, Innovation and Group Projects Division, SNCF



Chapter 4

Strengthening the Quantum Ecosystem

France is actively structuring its quantum ecosystem through initiatives that strengthen collaboration between research, startups, and industry such as France Quantum or Les Maisons du Quantique. By encouraging dialogue and co-development across sectors, these efforts aim to accelerate the maturation of quantum technologies and ensure their integration into the broader innovation landscape.

4.1 - Maisons du Quantique: Building Bridges Between Industry and Startups

Launched by Lab Quantique and HQI, Maisons du Quantique aims to bridge the gap between industry and startups, driving the adoption of quantum technology. In its first year, the initiative successfully brought together seven industrial co-founders and twelve startups, fostering collaboration in quantum research and development.

Maisons du Quantique is driven by three core missions: first, to **facilitate meaningful dialogue between industrial players and startups,** enabling the identification and exploration of quantum use cases that address complex challenges beyond the capabilities of classical computing. Second, the initiative prioritizes the **popularization and democratization of quantum science** by organizing educational events and partnering with experts to make quantum concepts accessible to both professionals and the wider public. Lastly, Maisons du Quantique is dedicated to **talent attraction,** exemplified by its inaugural Quantum Job Fair, which connected over 80 students from leading universities with ten companies, resulting in approximately 20 internship placements.

Beyond national efforts, Maisons du Quantique has also strengthened international collaboration by welcoming delegations from the Netherlands, Canada, Denmark, and Mexico, thereby reinforcing France's position as a dynamic hub for global quantum innovation and co-innovation projects.

4.2 - Corporate Engagement: How can a group like Crédit Agricole contribute to the development of the quantum ecosystem?

Quantum technologies have the power to transform financial services, and Crédit Agricole is leading the way not only to accelerate real-world applications through internal experiments, but also to provide strong support for the entire quantum ecosystem.

At the heart of this strategy is **FIRECA,** the Group's Innovation and Research Fund, which plays a pivotal dual role: **fostering internal quantum research projects and co-investing in high-potential startups across the French quantum ecosystem.** As highlighted by Peggy Bacati, CEO of FIRECA, this dual approach bridges Crédit Agricole's deep financial expertise with the technological breakthroughs needed to drive real-world applications. Several of these internal projects are conducted in close collaboration with startups from the French quantum ecosystem, helping to de-risk emerging technologies while reinforcing France's industrial base. In parallel, **Crédit Agricole CIB** is actively engaged in quantum experimentation. As described by Gaétan des Rieux, Senior Banker at CACIB, the bank has partnered with Pasqal, Quandela, and Multiverse Computing to **explore quantum real-world applications in liquidity optimization, capital allocation and risk management,** reinforcing its leadership in financial innovation.

Beyond internal innovation, **Crédit Agricole plays a decisive role in financing the next generation of quantum startups. Through Supernova Invest, a leading deep tech investment firm supported by Crédit Agricole via Amundi and the CEA, the Group channels venture capital into groundbreaking companies such as Alice & Bob,** which is working on fault-tolerant quantum computing. Supernova's approach to quantum investment is driven by a clear vision of the sector's future. While substantial revenues are expected in the next decade, today's quantum startups require significant operational and capital expenditures to develop their technologies. Étienne Moreau, partner at Supernova Invest, explained that **Supernova focuses on identifying companies that not only possess technological excellence but also have the potential to transition into commercially viable businesses with broad market appeal.** By supporting these emerging leaders, Supernova, and by extension, Crédit Agricole strengthens France's position as a hub for quantum innovation.

At the local level, **Crédit Agricole's Caisses Régionales are also contributing to the development of the deep tech ecosystem by offering tailored financing and advisory support to early-stage startups.**

On the private wealth side, **Indosuez Wealth Management** acts as a strategic bridge between technological innovation and private capital. Through its StartUp Connections program, Indosuez offers its clients, including entrepreneurs, family offices, and high-net-worth individuals, exclusive access to investment opportunities in fast-growing technology ventures, including those operating in the quantum field. As emphasized by Benoît Bourdin, Venture Markets Manager at Indosuez, this initiative reflects a rising demand from clients to diversify their portfolios through exposure to strategic and forward-looking sectors.

To reinforce its long-term commitment, Crédit Agricole was the first financial institution to join **France Quantum** in 2022, and more recently, the **Lab Quantique** in 2024. These memberships demonstrate the Group's long-term commitment to engaging with the academic, industrial, and public stakeholders shaping France's Quantum ecosystem.

"We are willing to share with other corporates our knowledge of the sector [...] to show them how we can collaborate in a different way than a pure banking relationship."

Gaétan Des Rieux, Senior banker, Crédit Agricole CIB

"You need the support, the relationships of a broader ecosystem – you can't develop it all. [...] It's important for us that the companies we invest in develop relationships with all the value chain."

Étienne Moreau, Partner, Supernova invest

4.3 - AQADOC: A Strategic French Consortium Tackling Distributed Quantum Computing for Energy Applications

Most players in the field of quantum computing today agree that the preferred way to scale up quantum computing is through the parallelization of quantum processors using quantum interconnects. **The Paris-Region funded project AQADOC, led by Welinq and EDF, aims to develop distributed quantum algorithms and quantum networking solutions to reach a quantum advantage for the Energy sector. Over the next three years, Welinq and EDF will join forces with Pasqal, Quandela, the computer science lab of Sorbonne Université Lip6, Le Lab Quantique and Teratec to make distributed quantum computing a reality.**

AQADOC aims to develop and implement quantum algorithms specifically tailored to critical energy sector applications, ranging from battery aging simulations to complex logistical optimizations, that are currently beyond the reach of classical computing. Over the course of three years, the project will focus on:

- Developing distributed quantum algorithms compatible with heterogeneous quantum hardware architectures.
- Advancing quantum interconnection technologies and protocols to enable coherent entanglement across distinct quantum processors.
- Accelerating the adoption of distributed quantum computing clusters within industrial environments, by targeting energy sector use cases.

AQADOC exemplifies a collaborative, multi-disciplinary approach involving public and private stakeholders, underscoring the vital role of regional and national support in fostering technological sovereignty and competitiveness in the emerging quantum economy. By pioneering distributed quantum computing solutions adapted to the needs of the energy industry, AQADOC will contribute to the emergence of a robust quantum ecosystem in France, reinforcing the country's position as a leader in quantum technologies and supporting sustainable innovation aligned with global technological trends.

"In this race, we want France and the French ecosystem to lead on the networking of quantum computers. [...] AQADOC is not only a very ambitious project from a scientific point of view but also very important for structuring and federating the French ecosystem around the topic of distributed quantum computing."

Tom Darras, CEO & Co-founder, Welinq

4.4 - HQI: towards strongly interconnected HPC and quantum communities

The France Hybrid HPC-Quantum Initiative (HQI) is a flagship program of the French national quantum strategy, dedicated to bridging the gap between high-performance classical computing (HPC) and emerging quantum technologies. Steered by CEA and major academic and industrial stakeholders (GENCI, CNRS, Inria, Eviden, etc.), HQI pursues **two complementary pillars: The development of an hybrid HPC-QC platform and an academic and industrial research platform.**

A hybrid computing platform

Félix Givois presented the hybrid infrastructure centered around the Joliot-Curie supercomputer hosted at the TGCC (Très Grand Centre de Calcul), part of CEA, which will soon be succeeded by the Jules Verne exascale computer. Key components of this platform include:

- Quantum computer emulation capabilities, already available for users,
- Various quantum processing units (QPUs) that will be integrated with the HPC supercomputer via Eviden's Captiva platform,
- A robust communication and user support framework to engage and assist the community.

Currently, the platform offers emulation tools and active community engagement through communication, sponsorship of quantum hackathon and active presence at major events such as VivaTech with The Quantum Village. **The next phase involves deploying a neutral-atom quantum computer developed by Pasqal,** with installation underway and expected availability by the end of the year. Following that, a photonic quantum computer, owned by the EuroHPC Joint Undertaking, will be integrated.

Ultimately, the initiative aims to provide the HPC community with access to a diverse range of quantum technologies. Preparatory efforts are underway to enable access to spin qubit technologies as well as quantum communication links for distributed quantum computation. Sabine Mehr, Chief Quantum Projects Officer at GENCI, highlighted that the platform is available free of charge for both academic and industrial open research.

A Structured Three-Pillar R&D Program

Beyond infrastructure, **HQI is also a R&D project, structured in three domains:**

- The development of pilots and the implementation of a hybrid platform that integrates the supercomputer with various quantum processors
- The creation of application software libraries focused on optimization, machine learning, cryptanalysis, and the simulation of physical systems
- A deeper understanding of quantum computer physics, exploring how these machines operate and how to leverage their full potential

An Active Presence in the Quantum Ecosystem

Recognizing the need to build a geographically distributed ecosystem, HQI is launching a call for five "Maisons du Quantique" in different French regions, with €6.2M in funding to support local innovation hubs and promote regional-national coordination. The first "Maison du Quantique" led by Le Lab Quantique was inaugurated at Station F in 2023.

HQI has also supported the **creation of the collaborative consortium "The Paris Region Quantum Pack",** which brings together partners to work on industrial use cases provided by leading companies. These use cases are executed on the HQI platform. The initiative has been so successful that it has already enabled the launch of 13 projects.

The HQI initiative reflects France's strategic commitment to hybrid computing leadership, blending robust HPC capabilities with diverse quantum technologies. Through infrastructure, research, regional development, and international partnerships, HQI is creating the foundation for a scalable, application-driven quantum future, by and for a strongly interconnected community.

"We have 6.2 million EUR to support the creation of five Houses of Quantum in five different regions. [...] We want to extend this initiative at a national and European level, and foster international collaborations on industrial use cases."

Sabine Mehr, Chief Quantum Projects Officer, GENCI

CONCLUSION

Building Tomorrow's Quantum, Today

Building Tomorrow's Quantum, Today

The quantum ecosystem is entering a new phase, marked by tangible action. Quantum technology is no longer confined to the realm of theory. It is becoming a strategic necessity and a key driver of competitiveness, sovereignty, and innovation. The testimonies shared at France Quantum underscore a shared conviction: quantum is not just coming, it is already here, and now is the time to act.

OVHcloud's commitment reflects this urgency. Through the deployment of six quantum emulators on its cloud platform and the acquisition of its first quantum machine from Quandela, the company is taking concrete steps toward real-world applications, particularly in cybersecurity. OVHcloud is also actively building a robust ecosystem, partnering with academic institutions and supporting startups to structure a broader and more accessible quantum infrastructure across Europe.

"If your company is making one billion in revenue, you should invest at least one million per year in quantum."

Octave Klava, Founder, OVHcloud

This pragmatic and forward-looking approach resonates with the vision of Crédit Agricole, whose Group Chief Digital Officer, Éric Caen, situates quantum within the continuum of historical transformations supported by the bank, from rural electrification to renewable energy. He sees quantum not just as a technological shift, but as the continuation of a legacy: investing in the future, in progress, and in collective well-being.

"We believe that thanks to quantum computing, tomorrow can be a better day and the future can look brighter."

Éric Caen, Group Chief Digital Officer, Crédit Agricole

Éric Caen draws a powerful parallel between past technological revolutions (railroads, the internet, space exploration) and the emergence of quantum computing: according to him, major technological leaps often emerge from crises. Today's complex global challenges (climate, health, energy) may very well be the catalyst for the next great leap. Quantum computing, particularly in combination with AI, holds unprecedented potential to address these complexities. Use cases are already emerging in energy, transportation, drug discovery, agriculture, and more.

As Damien Gromier, President of France Quantum, reminds us, France is approaching a pivotal moment: the conditions are coming together for the emergence of its first quantum unicorns. But funding remains a challenge, and capital alone will not be enough. True success will require clear use cases, structural alignment, international openness, and a strong connection between scientific research and industrial application.

In this context, France Quantum plays a pivotal role: not only as a platform for dialogue and visibility, but as a strategic instrument for mobilization and coordination. It brings together stakeholders across sectors to ensure that France and Europe can play a leading role in shaping the quantum future.

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