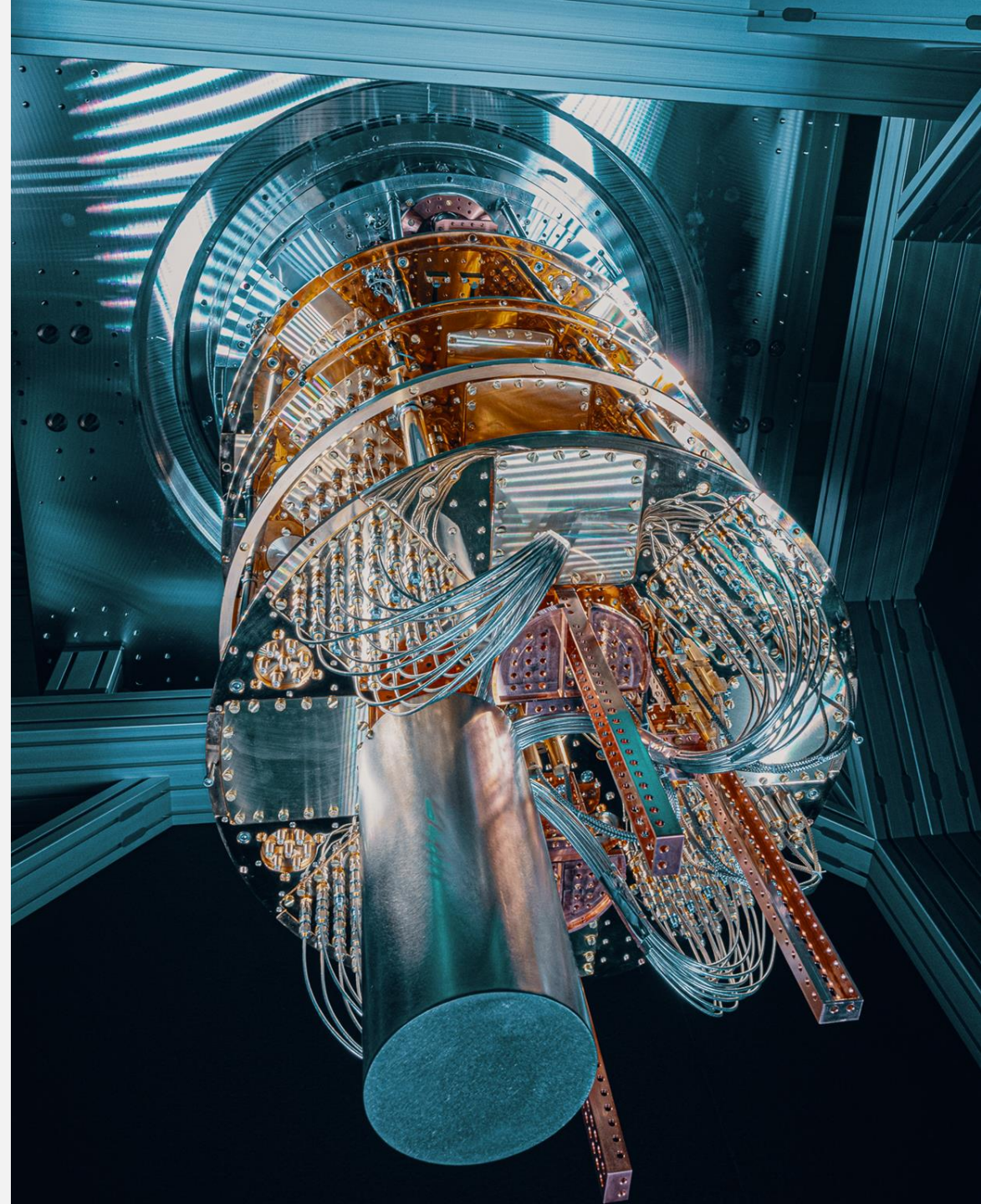


Scaling challenges of quantum computing - IQM approach

TQCI seminar 2024

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Head of Product

IQM



Overview



- **Social**
 - How do we educate more experts?
- **Ecosystem**
 - How do we avoid painting ourselves into a corner?
- **Algorithms**
 - What are the key requirements when implementing algorithms on hardware?
- **Hardware**
 - This is what you all expect me to talk about

IQM Spark™

Start Your Quantum Journey

For universities and research labs

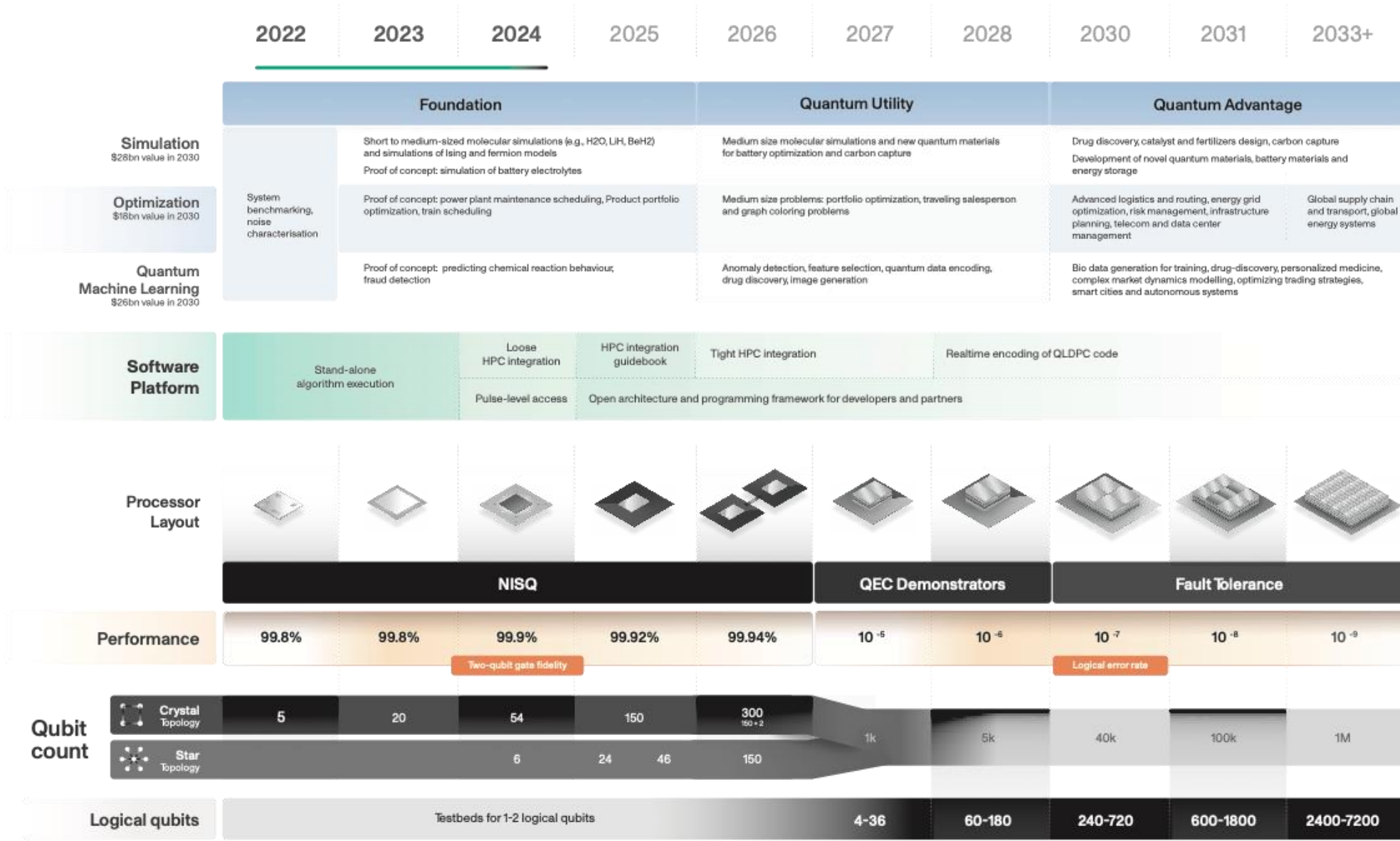
Our **5-qubit** superconducting quantum computer, brings **affordable** and **easy access** to quantum computing with custom learning experiences for future scientists, developers, and innovators.

IQM



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Development Roadmap



Processor layouts are for illustrative purposes only and do not represent the actual design.
Two-qubit-gate error refers to demonstration devices consisting of two qubits and a coupler only.
The fidelities get transferred system-level with a delay.

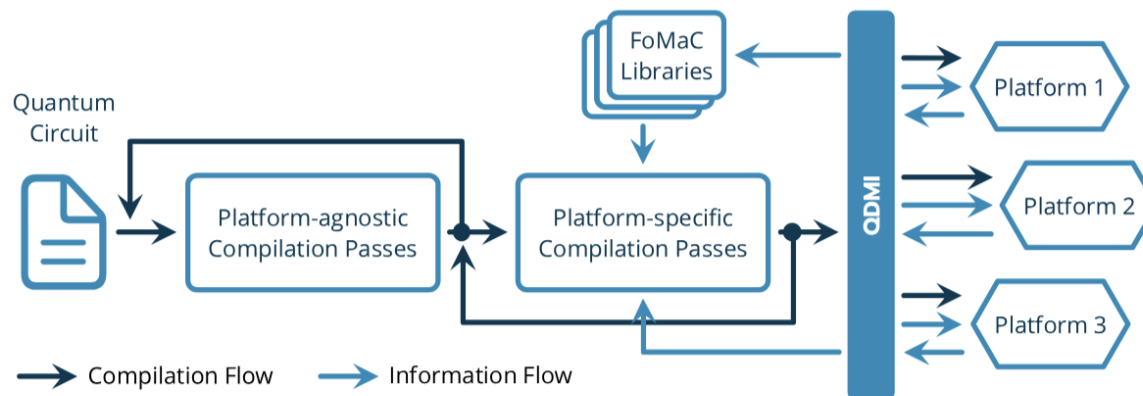
Timeline corresponds to first demonstration systems.
First on-premise delivery is 12-18 month available from first demonstration.



QDMI — Quantum Device Management Interface

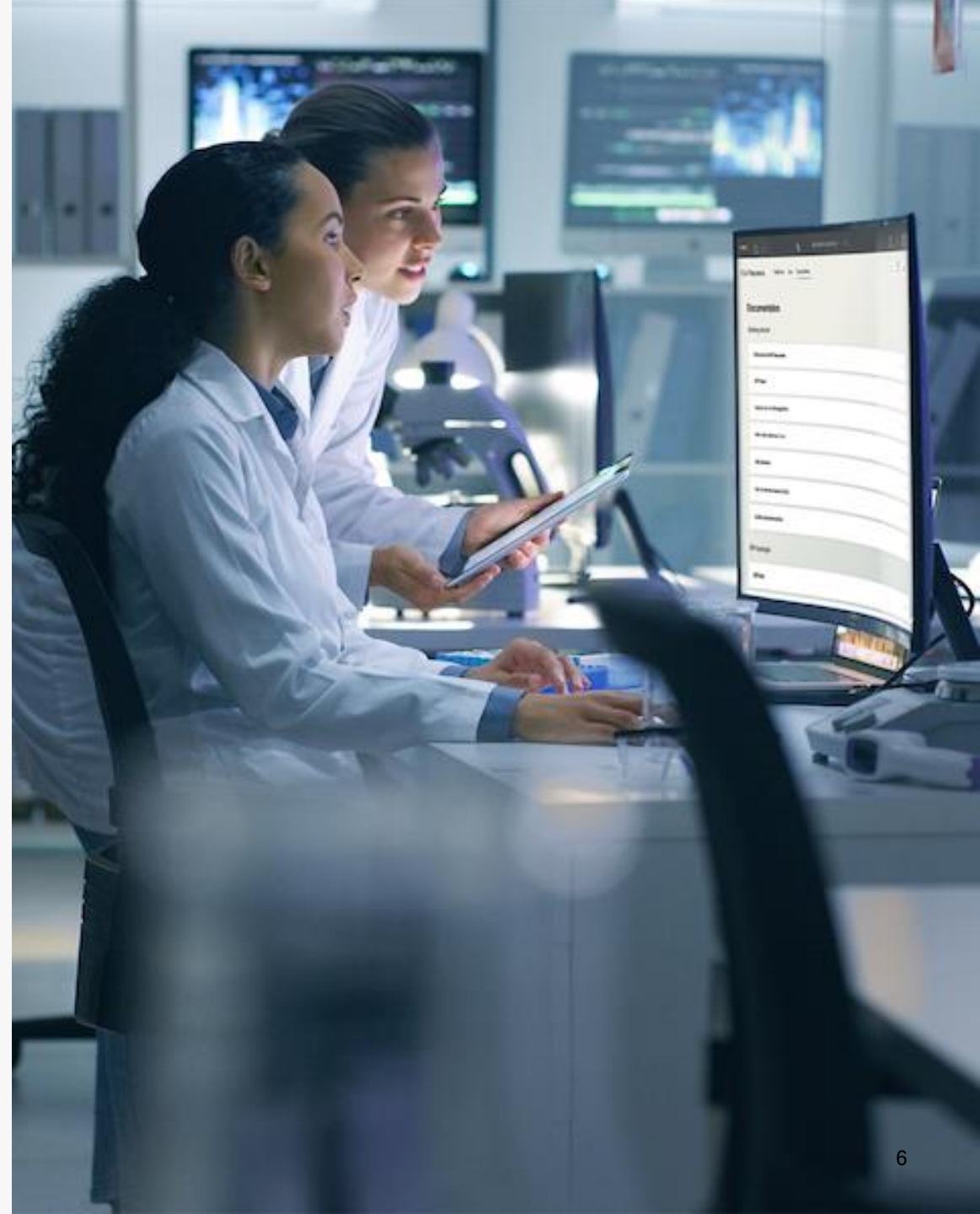
 DOCUMENTATION

The Quantum Device Management Interface (QDMI) is the central part of the Munich Quantum Software Stack (MQSS)—a sophisticated software stack to connect end users to the wide range of possible quantum devices. It enables the submission to and the control of gate-based quantum systems and enables software tools to automatically retrieve and adapt to changing physical characteristics and constraints of different platforms. QDMI strives to connect the software and hardware developers, mediating between their competing interests, bridging between technologies, and eventually providing corresponding figures of merits and constraints to be considered. QDMI is therefore the method of choice for integrating new platforms into the MQSS and for software tools to query information from these platforms. QDMI is provided as a collection of C header files to allow fast integration into an HPC environment.



Algorithms

- In our (and most player's) roadmap we transition from NISQ to FTQC.
 - But this is not a binary choice!
 - There will be a smooth transition
 - How will EM and partial QEC interplay?
 - Tradeoff: Speed vs fidelity
 - Resource theories missing
- Quantum algorithms must be integrated into hybrid workflows (probably with HPC) without abstracting too far



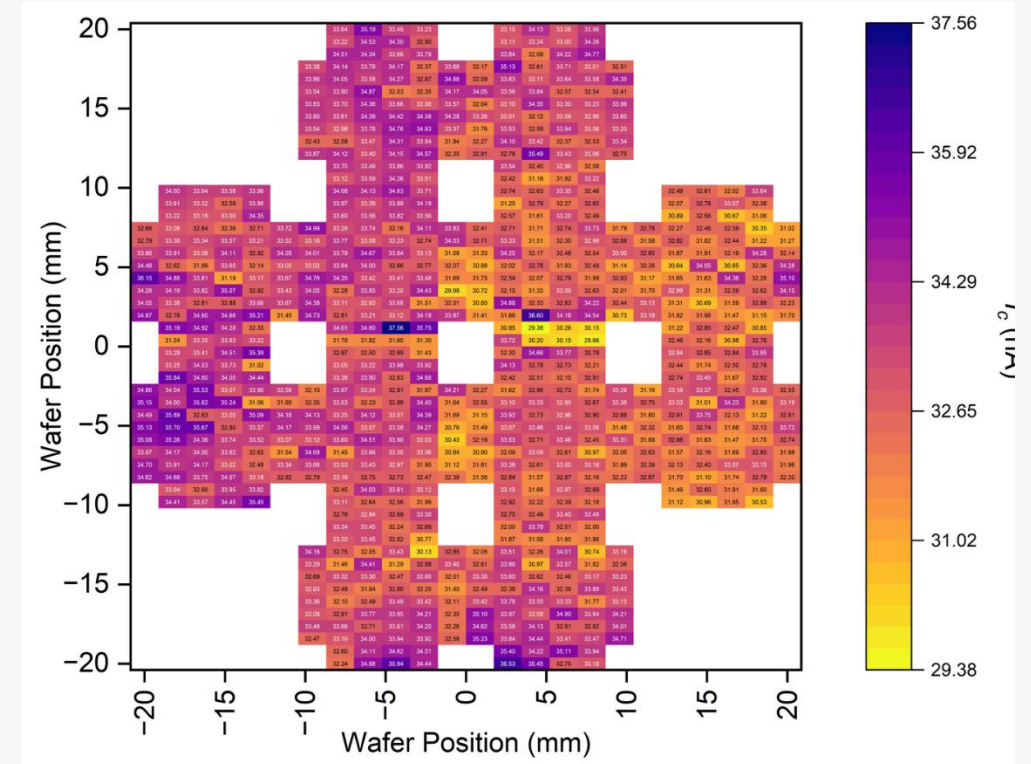
Hardware challenges



- We strongly agree with the previous speakers
- Electronics scaling
 - Current providers go to 1000qb range
 - They can maybe push this to 10 000qb
 - At that range the price will start to overtake all the other components
 - And the reliability needs to be increased dramatically. We cannot have broken control electronics!
 - The electronics also need to be integrated with QEC decoder logic!
- Long-distance couplings for qLDPC codes
 - 3D integration with qubit connections across layers needs to be developed
 - IQM Star making use of computational resonators gives is some basic building blocks
 - IQM Star and IQM Crystal merger for FTQC
- Error rates
 - We see that transmon technology can bring us comfortably into the 99.9%-99.99% fidelity range

Hardware challenges

- Josephson Junction uniformity
 - Even with 100% yield, we will need high enough uniformity
 - The industry will need to learn from semiconductor industry trilayer process
 - IQM has F1 pilot line fabrication facility in operation - Next gen fabrication facility needs to be develop: yield, repeatability, throughput



Let's start your quantum journey together!



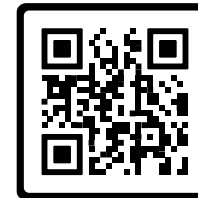
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Got questions?
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