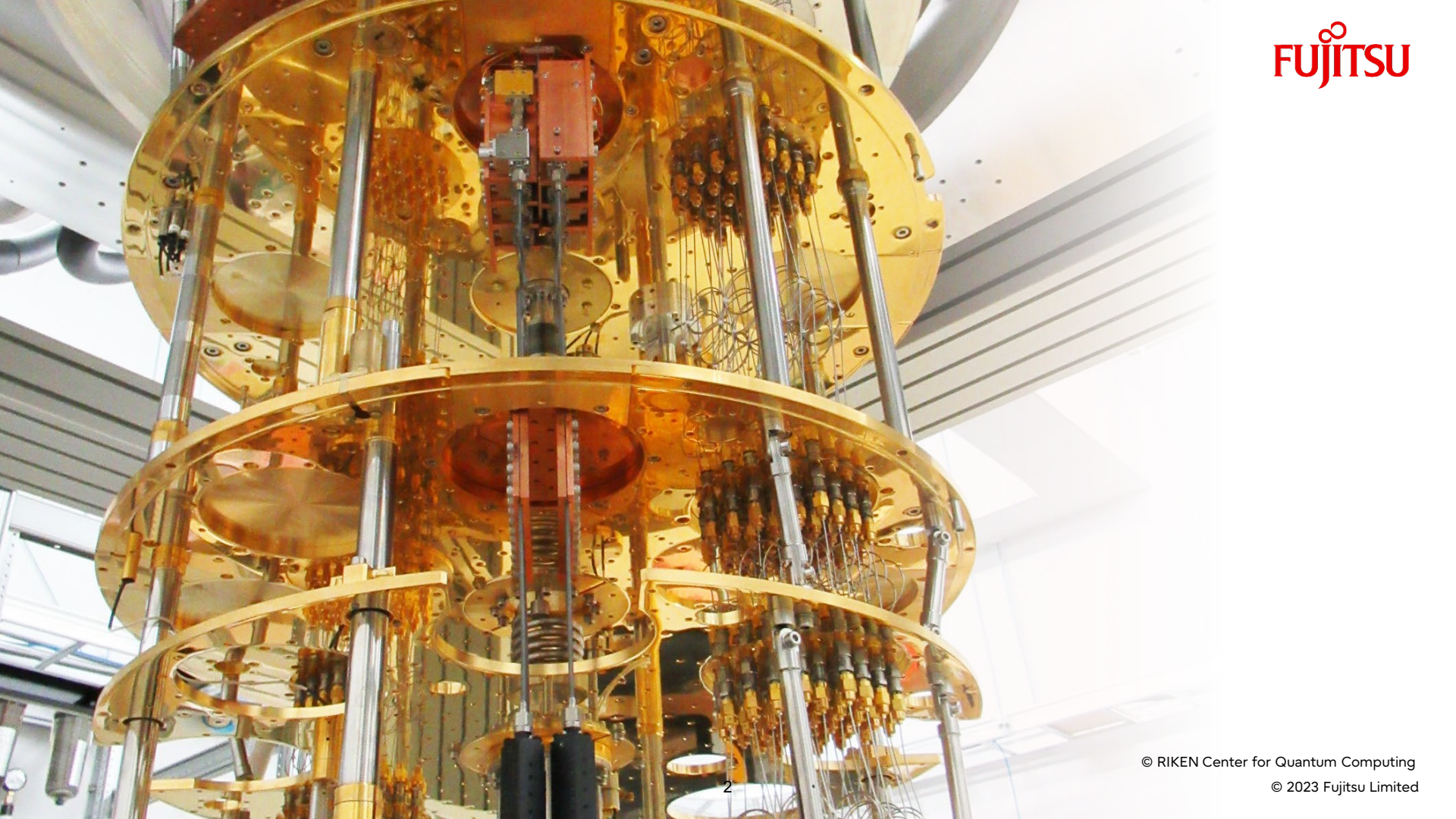


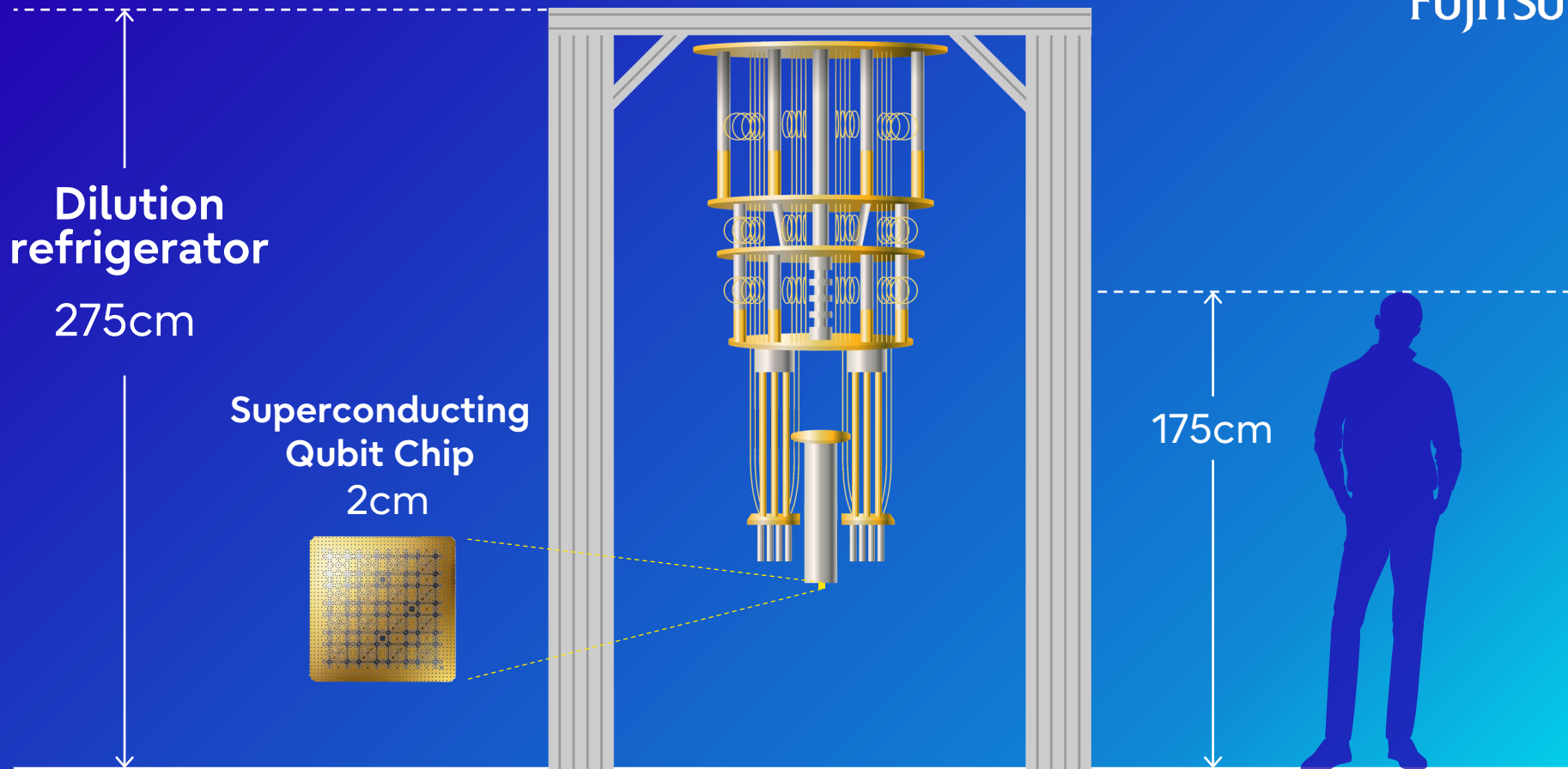
# Superconducting Qubit Chip

Fujitsu Research, Fujitsu Limited  
September, 2023



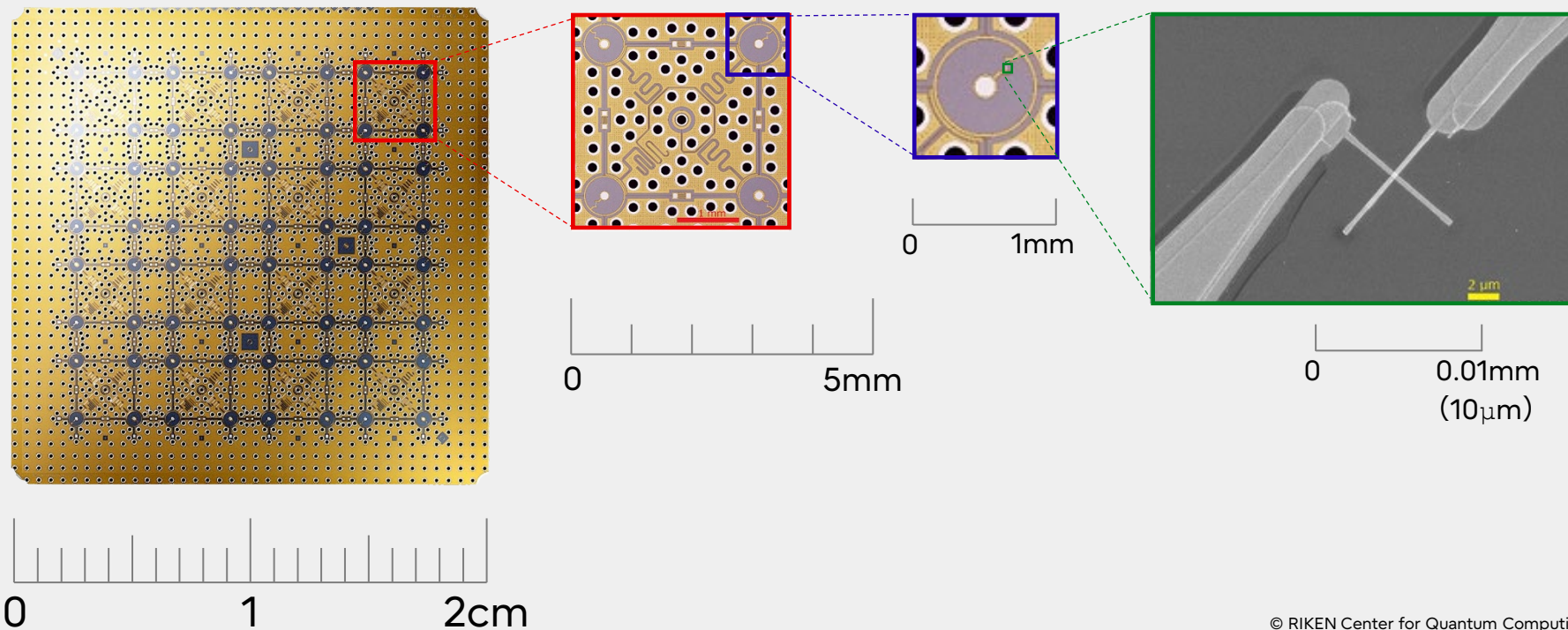


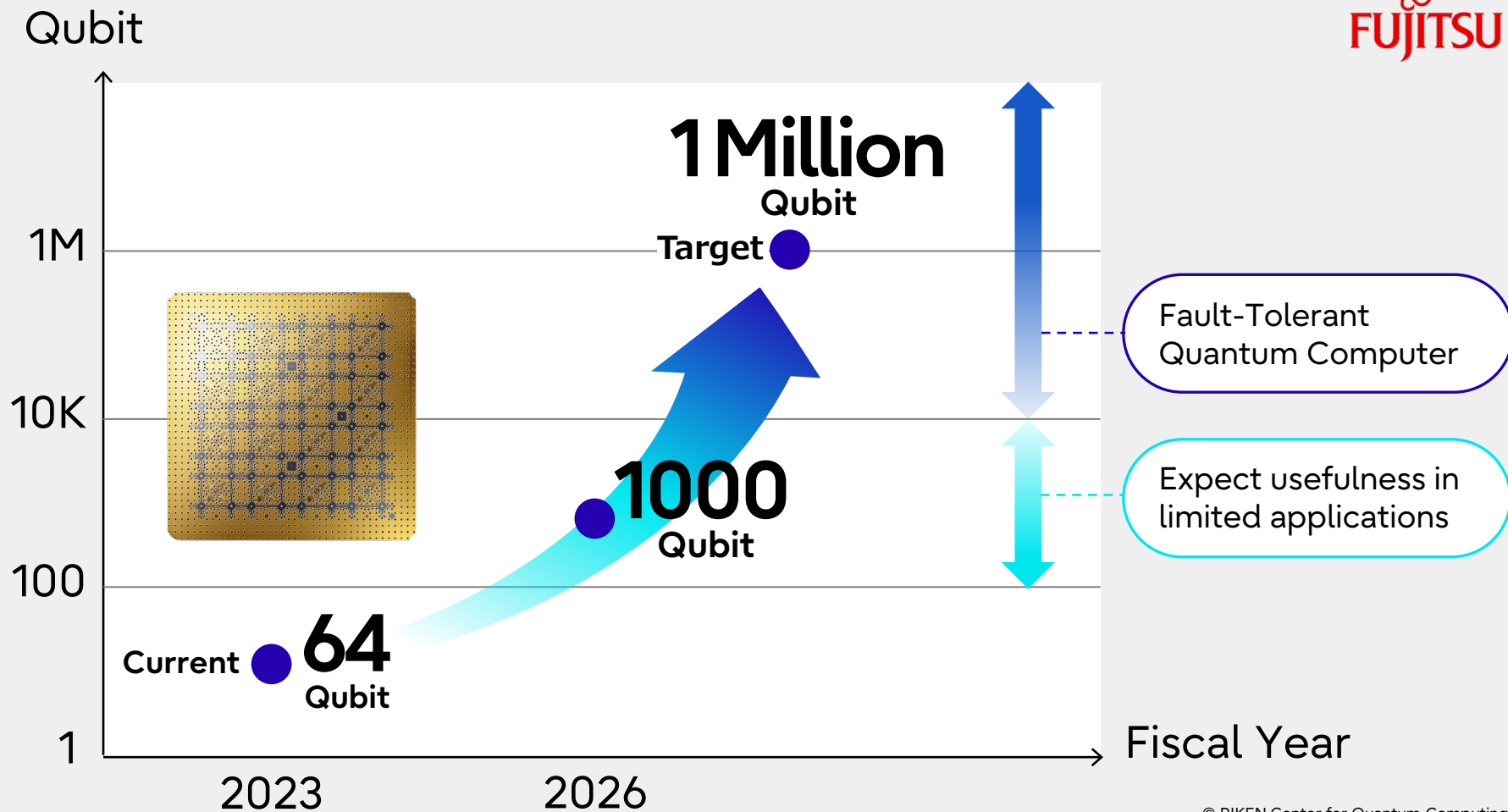




8 x 8  
= **64** Qubit

**1** Qubit





# Superconducting Qubit Chip

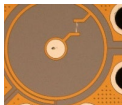
- TSV: Through-Silicon Via

- connecting between the bottom and top side of the chip

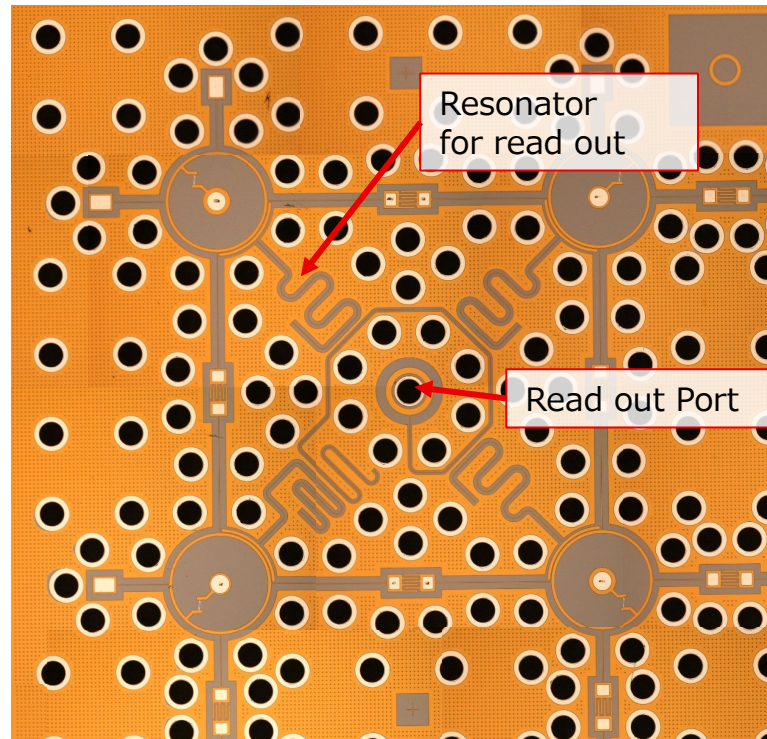
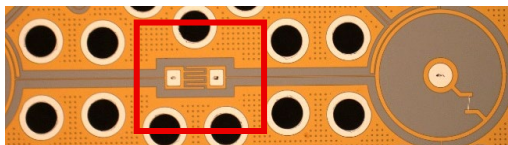


- Transmon

- Qubit
- it consist of Josephson Junction and the surrounding capacitor.

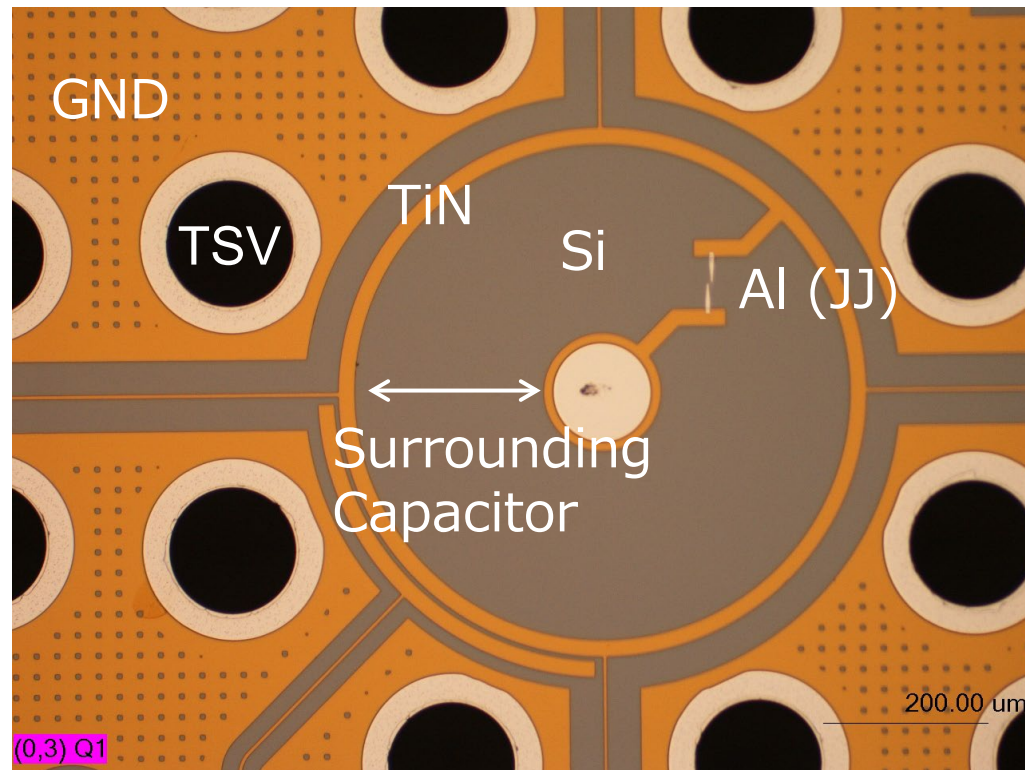
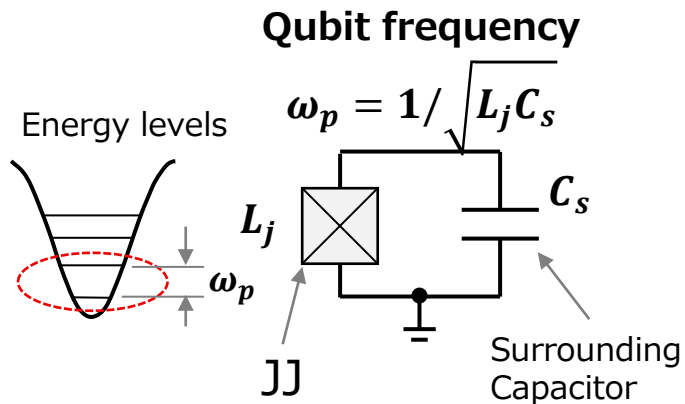


- Capacitor between Qubit

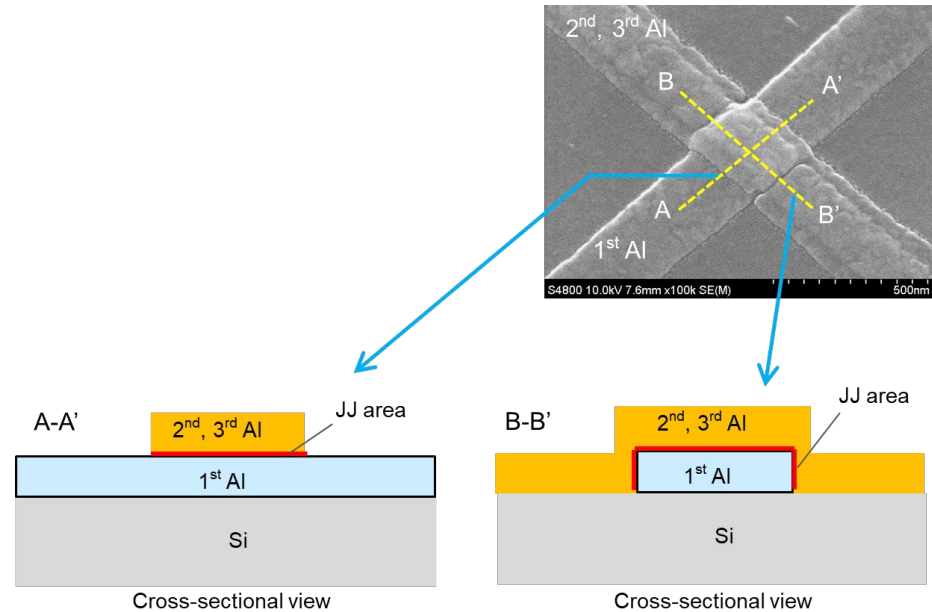
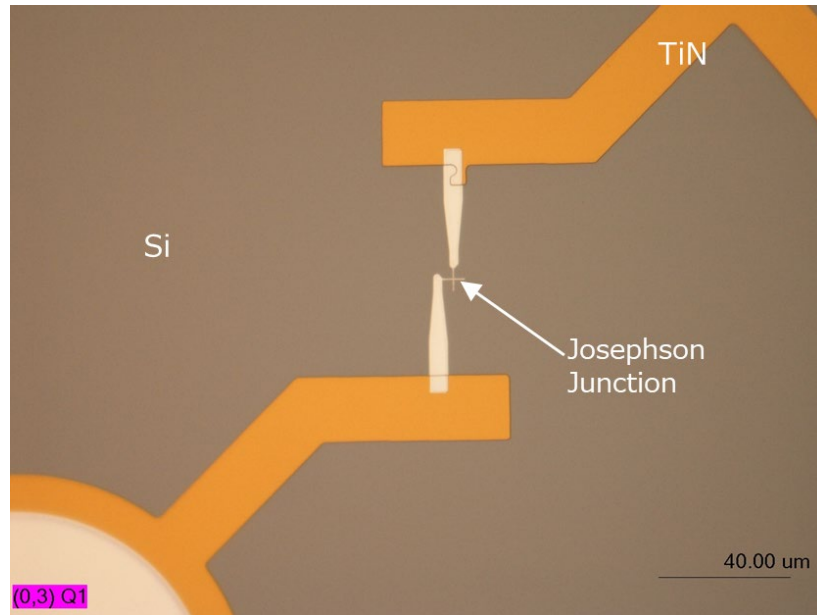




- substrate: silicon
- Josephson Junction(JJ)
  - Al-AlOx-Al
- Metal
  - TiN



# Josephson Junction





# Supplemental materials

You can use these materials for your explanation.

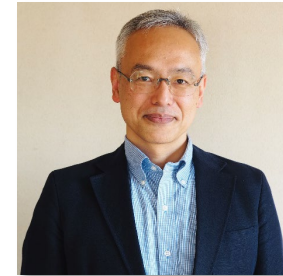
# Launched RIKEN RQC-Fujitsu Collaboration Center



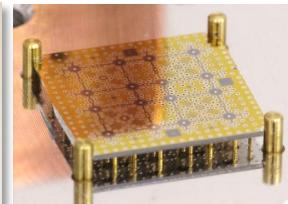
## Mission

April 1, 2021

- To develop hardware and software technologies to realize a quantum computer with as many as 1000 qubits
  - To develop applications using a prototype quantum computer.
- 
- RIKEN has strengths in qubit technology, including control, readout, and integration of qubits.
  - Fujitsu brings strong material, device, circuit, and system technologies.



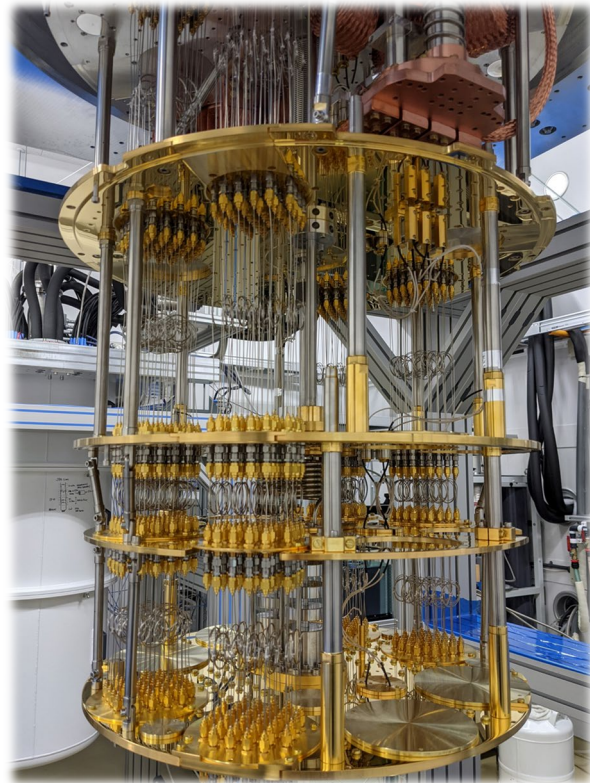
Prof. Nakamura



Superconducting qubit chip  
(By courtesy of RIKEN)

# Superconducting Qubit Technology

- Various parameters can be tuned as an “artificial atom”
- Relatively high gate speed is possible
- Fabrication technology similar to Si-CMOS can be used
- Cloud service for a system with  $>100$  qubits is available
- World's first 1000-qubit system is supposed to be realized soon using this technology
- Breakthroughs would be required to realize a system with  $>>1000$  qubits



Copyright; RIKEN Center for Quantum Computing

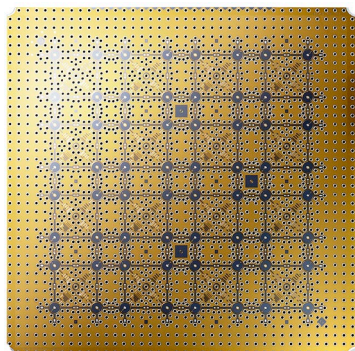
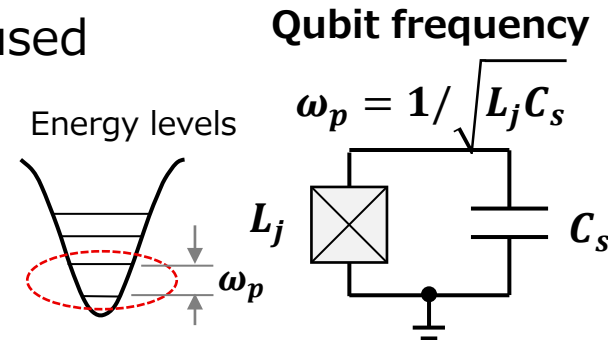
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# Development of Superconducting Qubit

- Two lowest levels in a superconducting circuit are used as a qubit

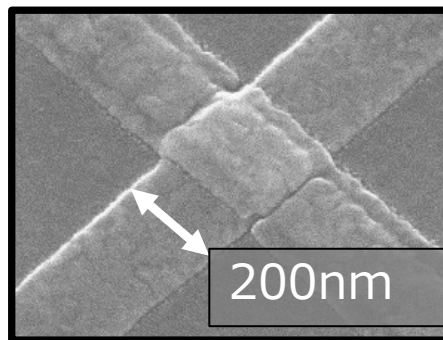
- Need to suppress unexpected variations of qubit frequency
  - Sizes of Josephson junctions should be well controlled
- Need to suppress noises to make a coherence time longer:
  - Materials and structures have to be well controlled



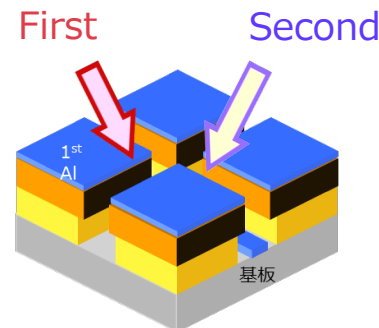
64-qubit chip



Qubit



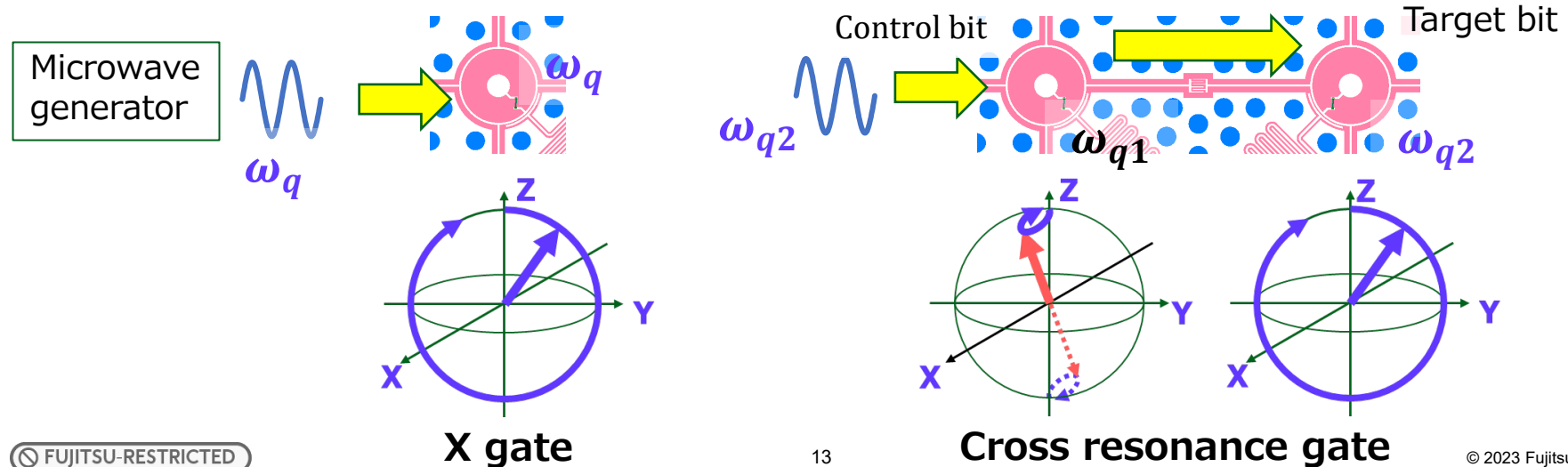
Josephson junction



Shadow evaporation of Al

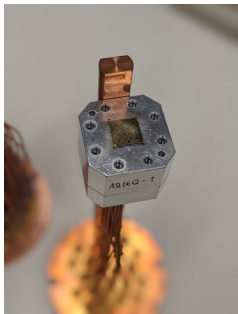
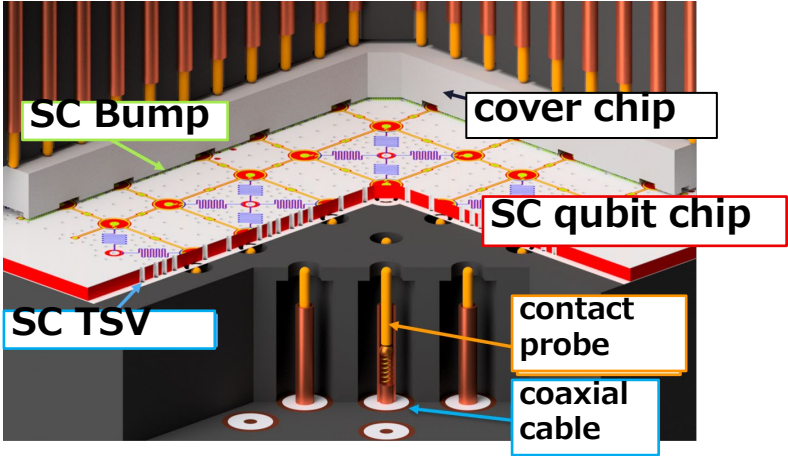
# Control and Readout of Superconducting Qubit

- Need technologies to control and read qubit states with high fidelity (>99%)
  - Microwave generator: Signal generation with small distortion
  - Signal transmission: Suppression of external cross-talk
  - Control of qubit states: Optimization of wave shape of control signal
  - Readout of qubit states: high-speed and high-fidelity readout, Low-noise amplification



# Superconducting Qubit Technology: Scalable Qubit Chip Design

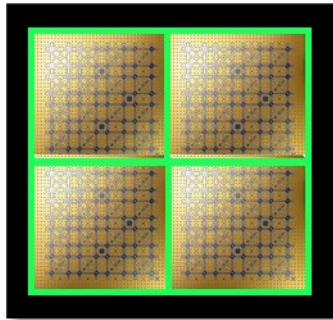
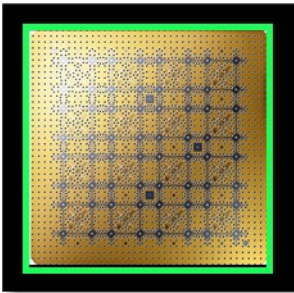
## 3D Contact



sample  
holder

64Q

256Q



and more

3D Contact to Superconducting qubits

Photos and Illustration:  
By courtesy of RIKEN



**Thank you**

