Press Conference

Fujitsu and The University of Osaka develop new technologies for chemical material energy calculations on early-FTQC quantum computers

Contributing to the early application of quantum computers
in drug discovery and new material development

March 25, 2026

Fujitsu Limited
The University of Osaka

1 Introduction to quantum computers, and The University of Osaka's activities towards the realization of quantum computers

Speaker

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Deputy Center Director
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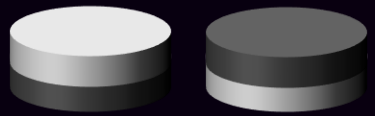
What is a quantum computer (QC)?

- **QCs will dramatically speed up calculations through quantum mechanical phenomena.**

Current computer

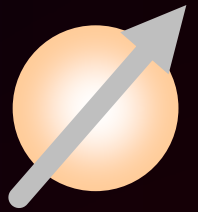
Either 0 or 1



2^N serial computations

Quantum computer

Superposition of
0 and 1



N bit

2^N parallel computations
by quantum entanglement

Exponential speed increase

Issues expected to be solved by QCs

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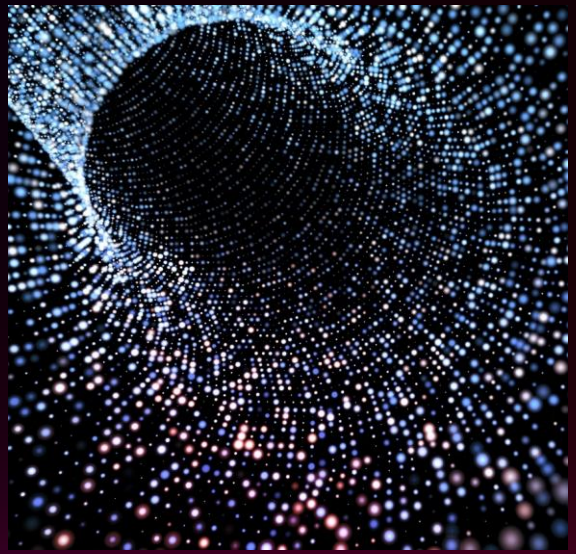
- **Complicated calculations that cannot be solved quickly and to high degree of precision using current computers**

Discovery of new materials and medicines

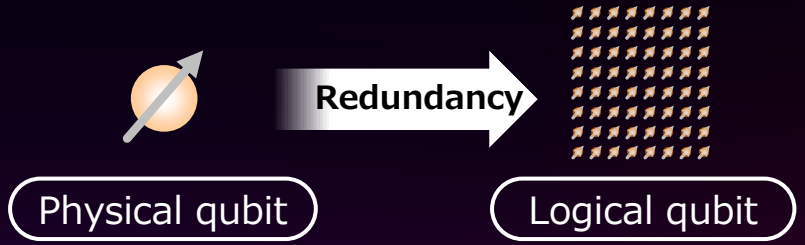
Predicting financial and economic trends

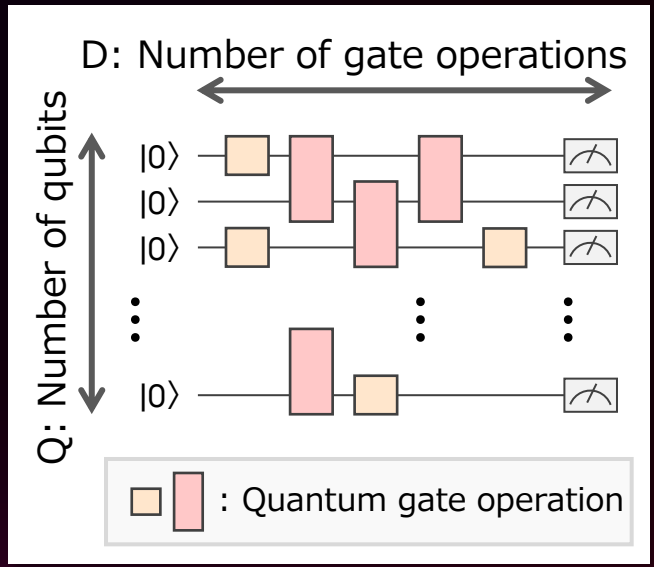
Discovery of new principles to transform industries



Quantum error correction (QEC)

- **Quantum error: noise changes the state of the qubit, leading to incorrect calculations**
  - Noise source: environment (thermal noise, etc.), control signal (fluctuation, etc.)
- **Fidelity of the overall calculation**
  $=(\text{fidelity of qubit})^{(Q \times D)}$
  - e.g. $(0.999)^{(50\ \text{qubits} \times 20\ \text{gate operations})}=0.368$
- **In QEC, one logical qubit is formed from many physical qubits**
  - Redundancy protects from quantum errors





Fault-tolerant QC（FTQC）

- **Framework for performing calculations with QEC.**
- **Combination of universal gates (operations on logical qubits) realizes all kinds of quantum calculations.**

Universal gate set（equivalent to AND, XOR, NOT in a current computer）

FTQC Architecture

Logical-CNOT gate	Logical-S gate
Logical-H gate	Logical-T gate

Ex）Phase rotation gate U with angle $\pi/128$*

$$U = \mathrm{HTSHTSHTSHTHTHTHTSHTHTSHTSHTSHTHTHTSHTSHTHTHTSHTHTSHTHTHTHTHTHTHTSHTSHT}$$
$$\mathrm{SHTHTSHTHTSHTHTHTHTSHTHTHTSHTHTSHTHTHTHTSHTSHTSHTHTHTSHTSHTSHTSHTHTSHTS}$$
$$\mathrm{HTSHTSHTHTSHTHTSHTSHTHTHTHTSHTHTHTHTSHTSHTSHTHTSHTSHTHTHTSHTHTHTHTHTS}$$
$$\mathrm{HTSHTHTHTHTHTSHTHTHTHTSHTHTHTHTHTHTH}\omega^{7}$$

* N.Ross and P. Selinger, *Quantum Information and Computation,* **16** (2016).

The University of Osaka's QC activities

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- **Center for Quantum Information and Quantum Biology (QIQB) established in March 2020**
  - The center consists of six research groups:
    - Quantum Computing, Quantum Information Fusion, Quantum Information Devices, Quantum Communications & Security, Quantum Measurement & Sensing, and Quantum Biology
  - The center promotes research among these and other academic fields
  - Selected as a **Quantum Software Research Hub** in the quantum technology field under the “COI-NEXT*” of JST**

QSRH 量子ソフトウェア研究拠点

*COI-NEXT: Program on Open Innovation Platforms for Industry-academia Co-creation
**JST: Japan Science and Technology Agency

QIQB center plays an important role in Japan's quantum technology innovation strategy

2 Fujitsu’s activities and developed technologies towards the realization of QC

Speaker

Shintaro Sato

Fellow
Head of Quantum Laboratory
Fujitsu Research
Fujitsu Limited

Fujitsu’s strategy for QC

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- **Cover all the technology layers with the world’s leading research institutions**
- **Put emphasis on software technologies, while working on several types of hardware**
- **Develop applications with end users by using Hybrid Quantum Computing Platform**

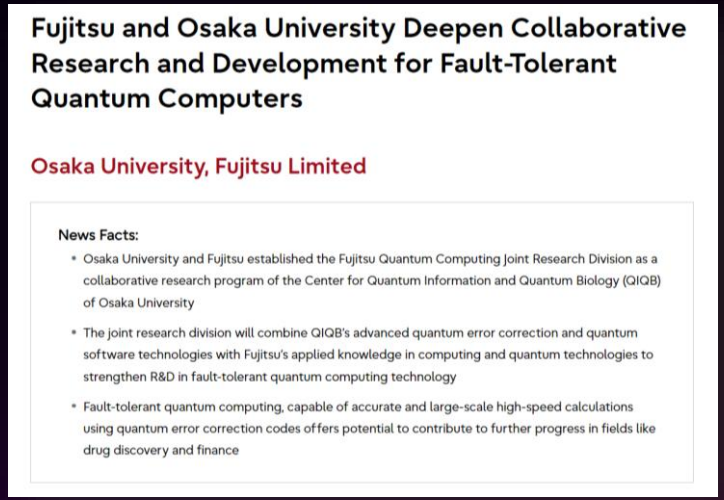
Quantum Application	Research with end-user input: **Materials** | **Drug discovery** | **Finance**		**FUJIFILM, Tokyo Electron, etc.**	**TU Delft**
Quantum Software	**QunaSys** Algorithm	**Keysight Technologies** Error Suppression	**The University of Osaka** Error Correction	
Quantum Platform	Middleware	Compiler	Cloud Technology	
Quantum State Control Quantum Device & Integration	**RIKEN** Superconducting Qubit	**TU Delft** Diamond Spin Qubit	Exploring other possibilities, Neutral Atom etc.	

Organization for joint research

- **Joint press release by The University of Osaka and Fujitsu(Oct. 1, 2021)**

Purpose **R&D of quantum software for FTQC**

- Quantum error correction, performance evaluation, and human resource development



Fujitsu and Osaka University Deepen Collaborative Research and Development for Fault-Tolerant Quantum Computers

Osaka University, Fujitsu Limited

News Facts:

- Osaka University and Fujitsu established the Fujitsu Quantum Computing Joint Research Division as a collaborative research program of the Center for Quantum Information and Quantum Biology (QIQB) of Osaka University
- The joint research division will combine QIQB's advanced quantum error correction and quantum software technologies with Fujitsu's applied knowledge in computing and quantum technologies to strengthen R&D in fault-tolerant quantum computing technology
- Fault-tolerant quantum computing, capable of accurate and large-scale high-speed calculations using quantum error correction codes offers potential to contribute to further progress in fields like drug discovery and finance

Fujitsu small research lab set up in The University of Osaka

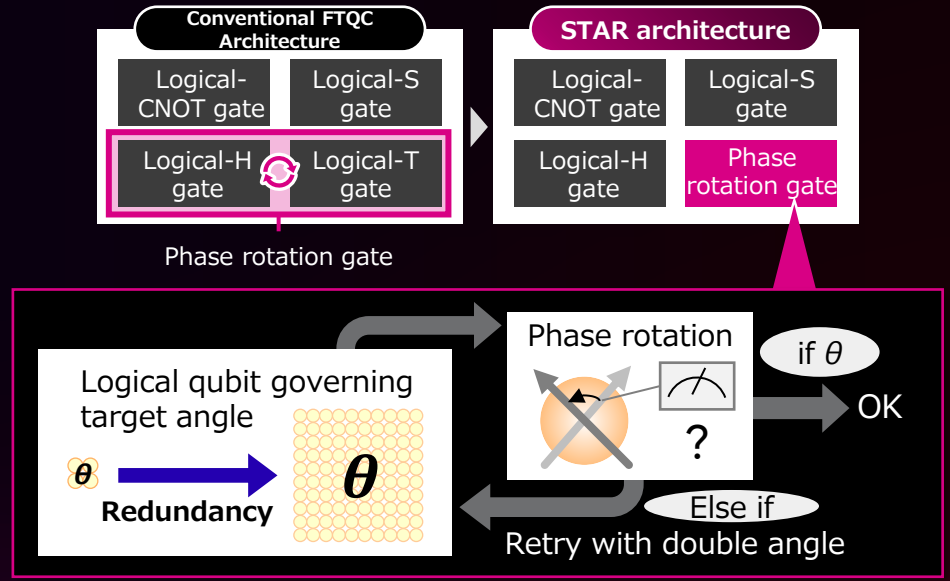
Recent topic of joint research ①

- **Unique QC architecture (STAR architecture*)**
- **Joint press release and press conference by The University of Osaka and Fujitsu (Mar. 23, 2023)****

Fujitsu and Osaka University develop new quantum computing architecture, accelerating progress toward practical application of quantum computers

Realizing highly accurate quantum error correction even for quantum computers with about 10,000 physical qubits

Osaka University, Fujitsu Limited



* Space-Time efficient Analog Rotation quantum computing architecture (STAR architecture)
** Fujitsu and Osaka University develop new quantum computing architecture, accelerating progress toward practical application of quantum computers (fujitsu.com)

STAR architecture ver. 1

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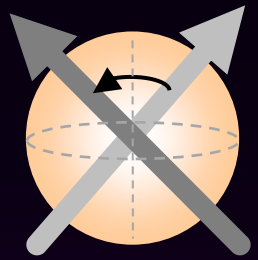
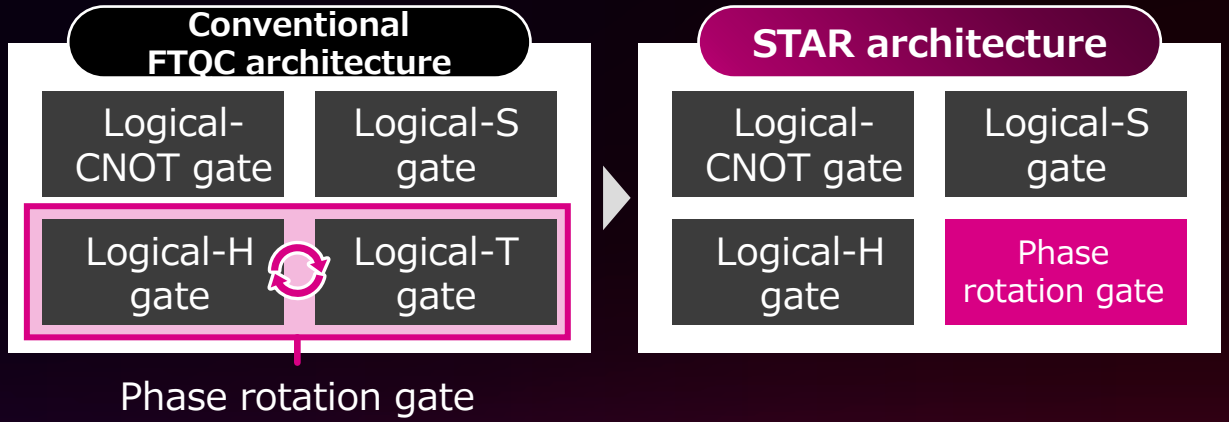
- **Realizing practical quantum computing with fewer qubits**
  - Efficiently perform phase rotation* (essential for quantum computing), reducing the number of qubits and quantum gate operations
  - Accuracy is limited because errors in phase rotation gate cannot be corrected.

Phase rotation

Target angle θ



Universal gate set



* Rotating a qubit by an arbitrary phase angle. Conventionally, T or H gate are operated many times.

Recent topic of joint research ②

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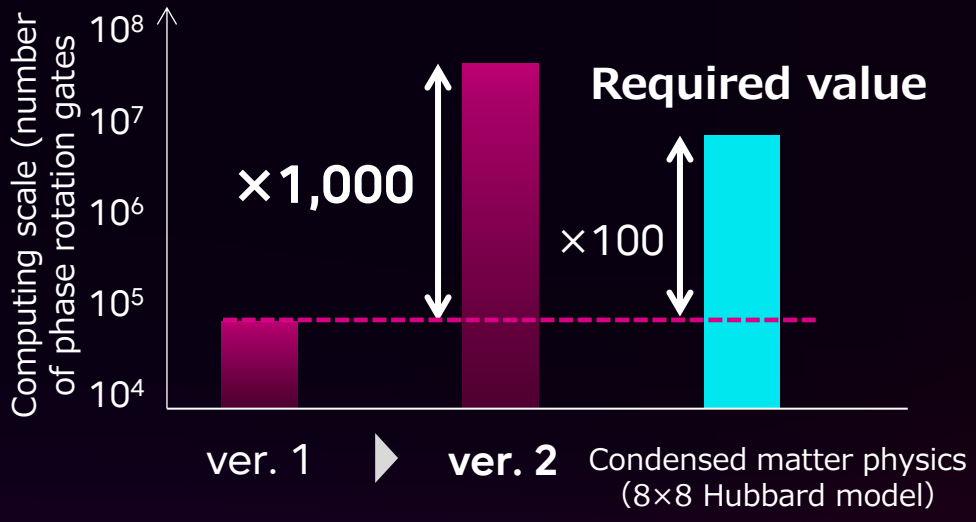
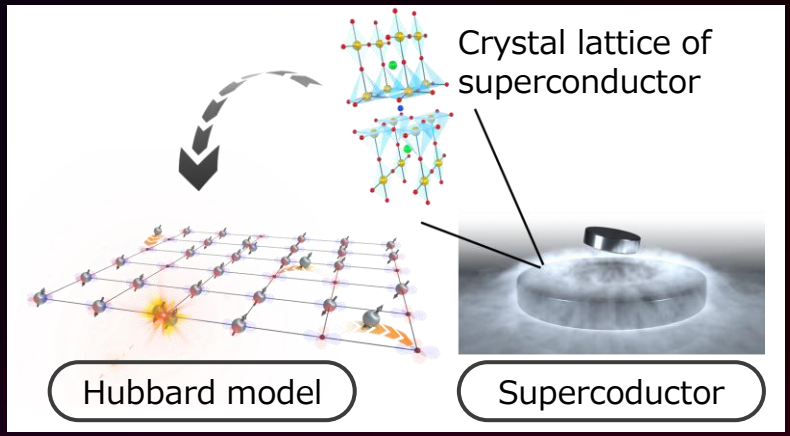
- **Press release for STAR architecture ver. 2 (Aug. 28, 2024)***
  - **Significantly improved the accuracy of phase rotation gates, expanding computing scale by 1,000 times**



Applicable to the analysis of condensed matter physics



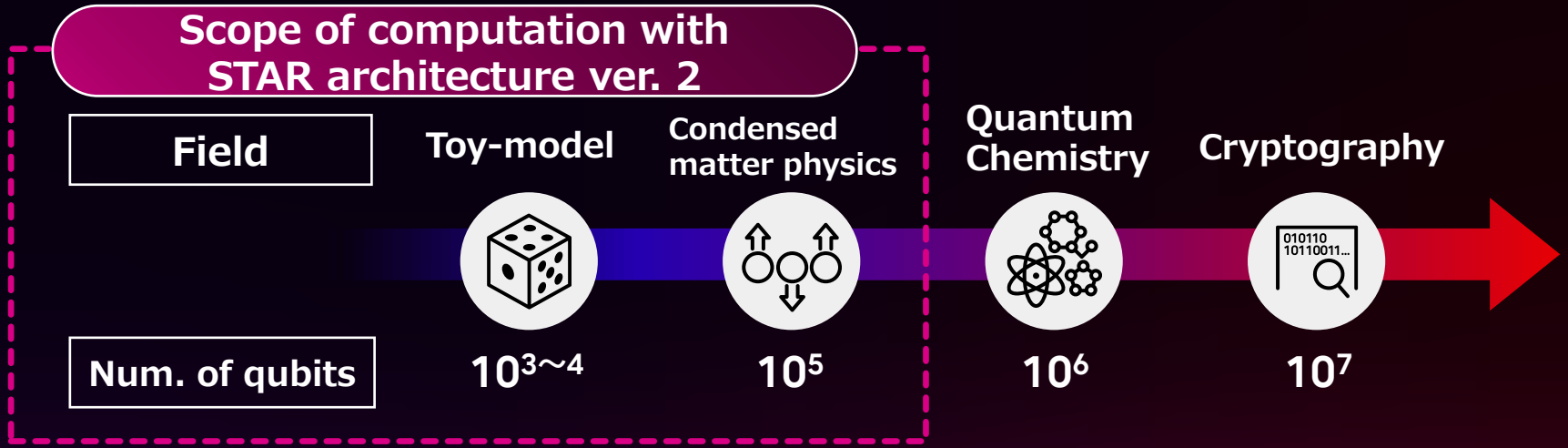
* Fujitsu and Osaka University accelerate progress toward practical quantum computing by significantly increasing computing scale through error impact reduction in quantum computing architecture (fujitsu.com)

Development of QC technologies for chemical material calculations

1. STAR architecture ver. 3
2. Molecular model optimization technology

Purpose of the development

- **Expanding the application scope of QC to larger-scale problems, specifically the analyses of chemical materials**
  - Chemical materials (molecules) are used in various industrial fields such as new material development and drug discovery



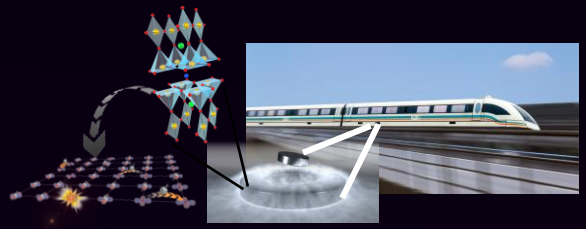
N. Yoshioka et al., *npj Quantum Information*, Vol.10 Art.45 (2024)

The chemical materials industry

- The chemical materials sector has an enormously large market size
- Our goal is to apply QCs of the Early-FTQC era to this field

Global market size (2025)

Target of condensed matter physics (Solid material model)



Superconductor $9.3B*1

×200~

Target of quantum chemistry (molecular model)

Drug manufacturing and discovery

$2.0T*2

Ammonia synthesis

$171.7B*3

Carbon recycling

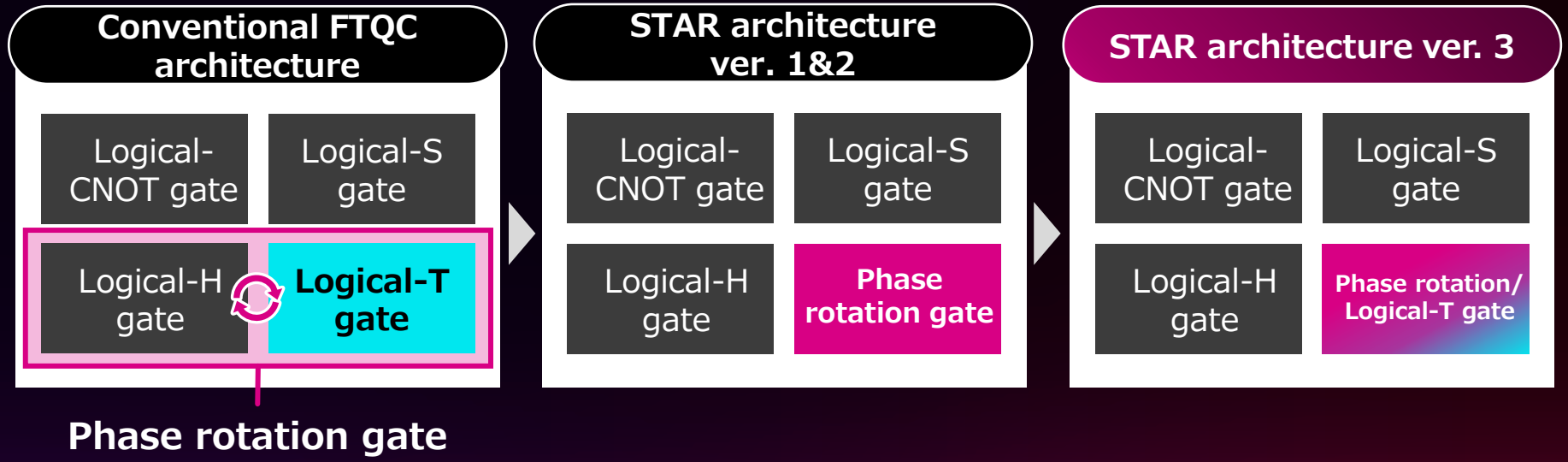
$17.4B*4

*1 Global Market Insights (2025), *2 Fortune Business Insights (2025) , *3 Straits Research (2025), *4 Fortune Business Insights (2024)

1 STAR architecture ver. 3

Overview of STAR architecture ver. 3

- **Improving computational accuracy by 10 times integrating phase rotation gates and logical-T gates**
  - Expanded the computational scale even with the same number of qubits
  - Relaxing requirements for QC: 0.01% to 0.10% (physical error rate)



Detail of STAR architecture ver. 3

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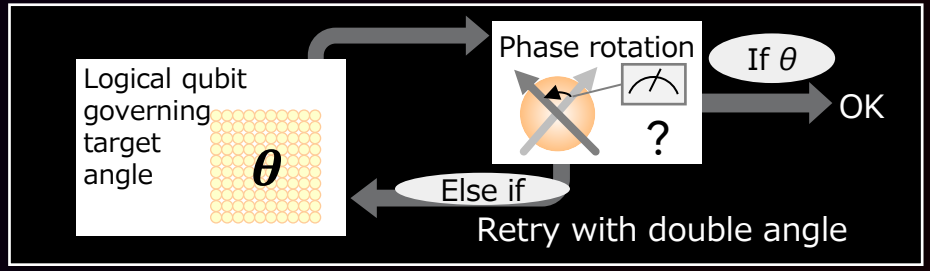
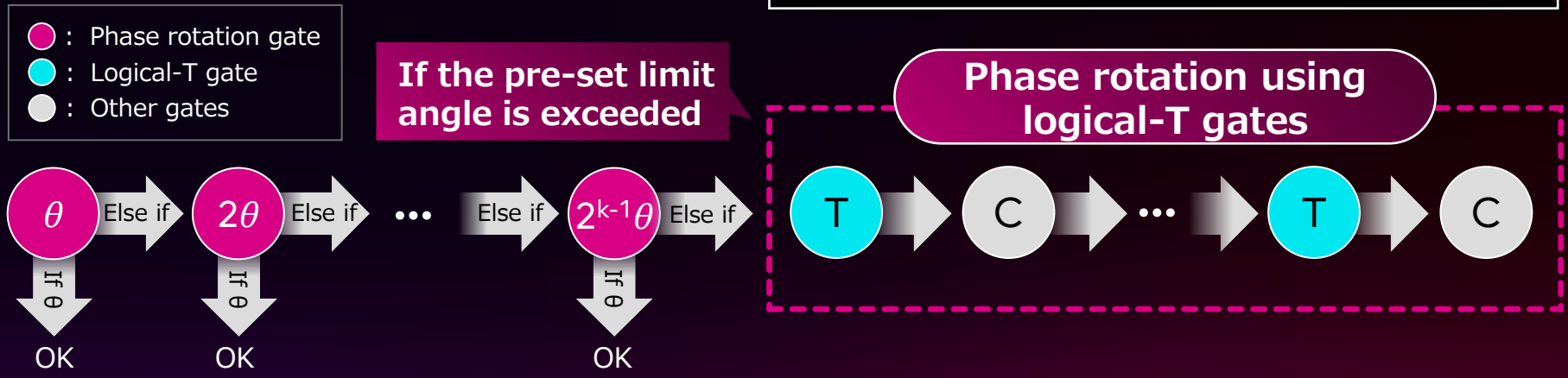
- **Switching from our phase rotation gates to phase rotation using logical T-gates**
  - Continuous failures in phase rotation degrades the accuracy
  - Shift to phase rotation via logical-T gates to avoid that situation

▼ **Unique phase rotation gate**





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2 Molecular model optimization technology

Overview of molecular energy calculation

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- **Generate quantum circuits from molecular models and QC outputs molecular energy**

Construction of molecular model

↓

Generation of quantum circuits

↓

Calculation with QC (STAR architecture)

↓

Molecular energy

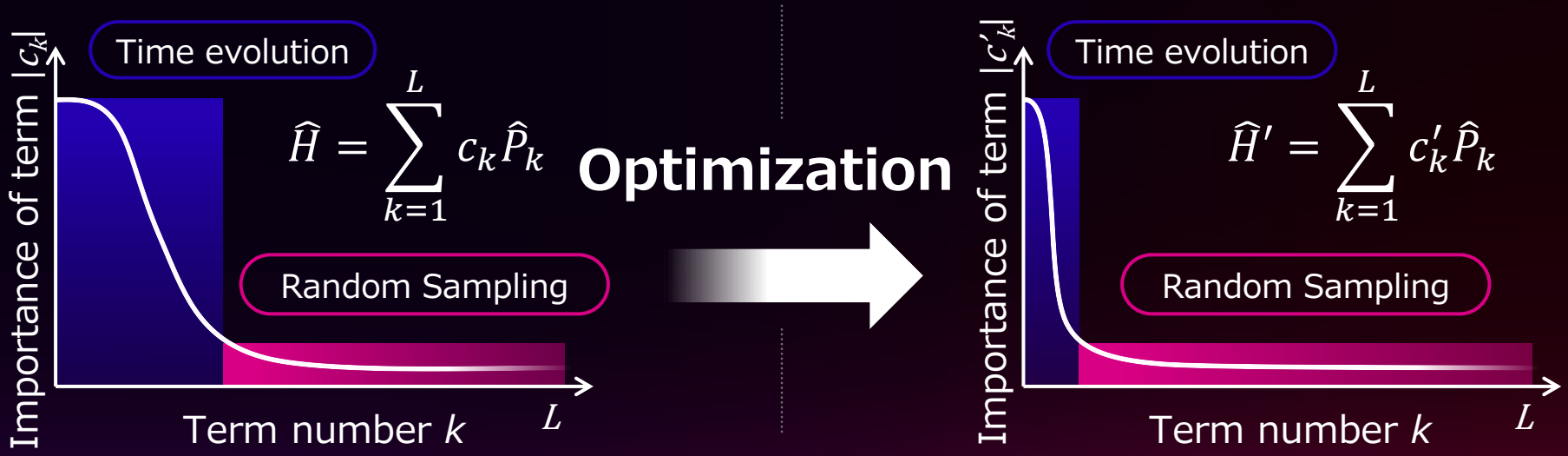
- Dividing the molecular model into multiple terms
- The two types of methods are:

$$\hat{H} = \sum_{k=1}^{L} c_k \hat{P}_k$$

Methods	Characteristics	Cost
Time evolution	High precision and time-consuming, for a single term	Higher cost for larger L
Random sampling	Random selection based on importance for multiple terms	Higher cost for larger $\lvert c_k \rvert$

Detail of molecular energy calculation

- **Optimize the balance between the two methods by transforming the molecular model while maintaining approximation accuracy, changing the distribution of importance**
  - Significantly reducing the number of gates in quantum circuits



The effect of newly developed QC technologies

Impact of physical qubit reduction

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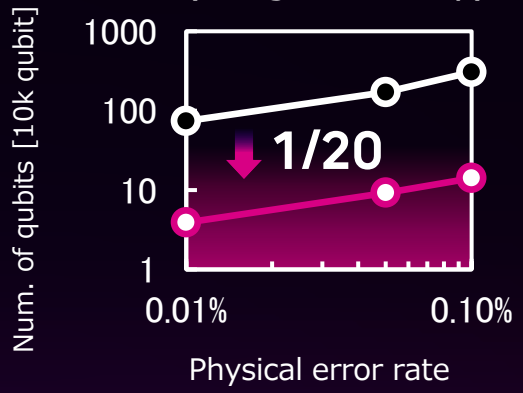
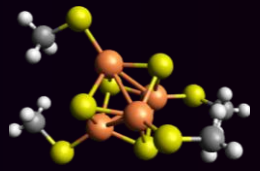
- **Energy calculations for industrially important chemical materials (computationally infeasible for supercomputers)**

Cytochrome P450

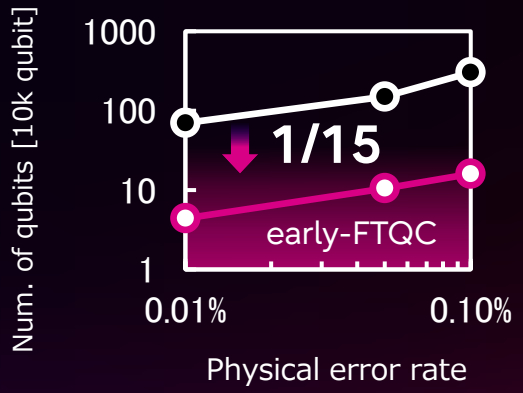
(Drug discovery)



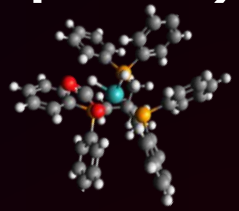
Fe-S Cluster



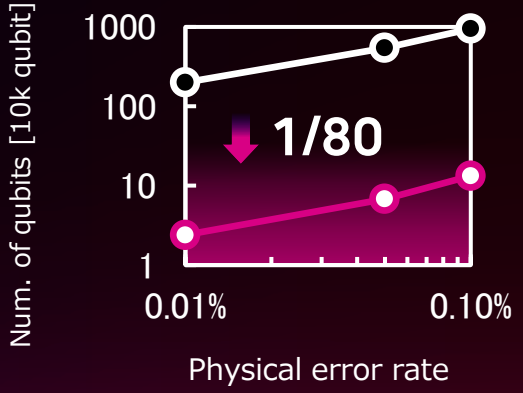
(Ammonia synthesis)



Ruthenium catalyst



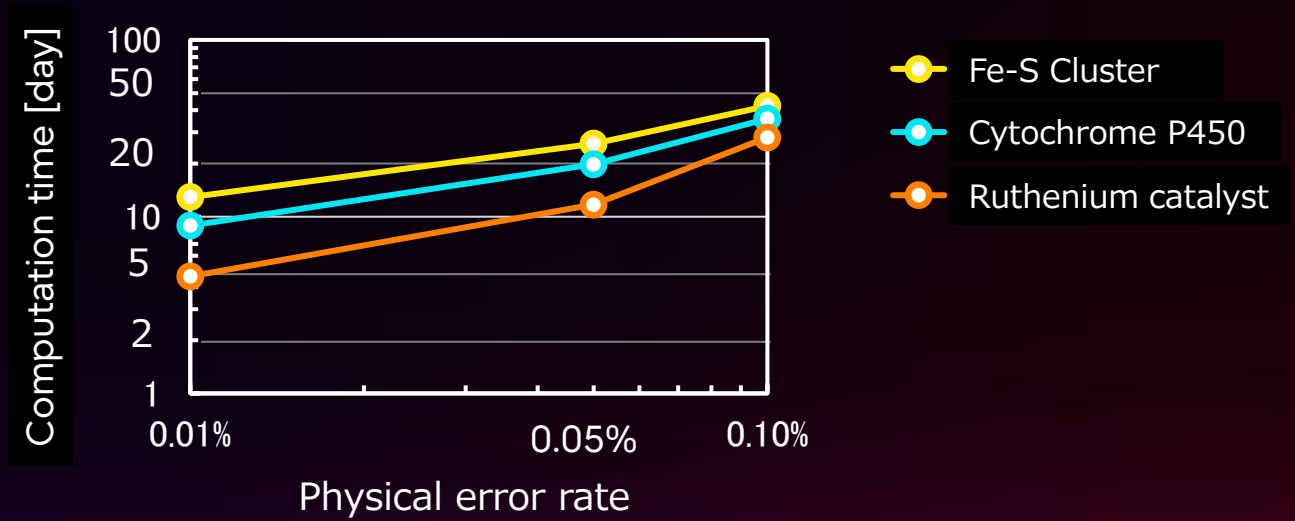
(Carbon recycling)



Conventional FTQC — Our method

Impact of calculation time reduction

- **Prospects for calculating energy within a practically viable time**
  - It is also possible to shorten computation time by performing parallel computations using multiple QCs



Summary of the effect

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- **When the physical error rate is 0.01%**

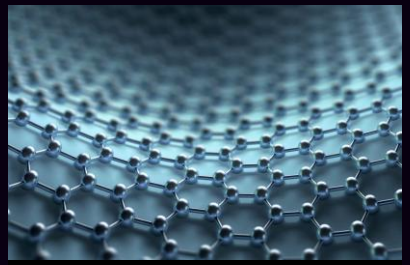
	Cytochrome P450 (Drug discovery)	**Fe-S Cluster** (Ammonia synthesis)	**Ruthenium catalyst** (Carbon recycling)
Conventional FTQC	0.74M qubits	0. 70M qubits	2.0M qubits
STAR architecture ver. 3	50k qubits、5k days	60k qubits、13k days	50k qubits、5k days
STAR architecture ver. 3 ＋Model Optimization	40k qubits、9 days	40k qubits、13 days	20k qubits、5 days

Contributes to the application of QCs in the chemical materials sector, which has an enormous market size

Future development

- We will further develop STAR architecture and related technologies to expand the practical application range of QCs in the Early-FTQC era

Condensed matter physics and quantum chemistry



- Development of next-generation battery
- Materials design (Automobiles, aircraft, and space shuttle)
- High performance solar battery opener

- Earth-friendly ammonia production
- High-efficiency hydrogen energy generation (artificial photosynthesis)

New application fields

- Solving advanced optimization problems (drug discovery, finance, logistics)
- Future prediction using quantum machine learning (finance)

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Thank you!