Introduction to Moonshot Goal 6

“Realization of a fault-tolerant universal quantum computer that will revolutionize economy, industry, and security by 2050.”

April 23rd, 2021

Program Director
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Professor, Graduate School of Engineering Science
Director, Center for Quantum Information and Quantum Biology
Osaka University

Program Director, Dr. KITAGAWA Masahiro

Professor, Graduate School of Engineering Science
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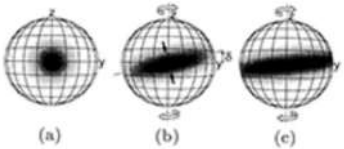
1983-1993 NTT Basic Research Laboratories
1993- Osaka University
2018- Cofounder QunaSys Inc. https://en.qunasys.com/
2018- Director, Quantum Information and Quantum Biology
https://qiqb.osaka-u.ac.jp/en/
2020- Program Director, Moonshot Goal 6
2020- Project Leader, Quantum Software Research Center
One of eight quantum innovation hubs in Japan

Life member of American Physical Society

Physical Review A 50th Anniversary Milestones

PHYSICAL REVIEW A



Squeezed spin states

For a long time, squeezing was the quintessential property of a quantum system, but the concept was mainly restricted to radiation fields. Kitagawa and Ueda generalized the formalism to the case of spin systems and provided a recipe for experimental manipulation, making squeezing available into the realm of atomic systems and opening the way for applications in metrology.

https://journals.aps.org/pra/50th

Squeezed spin states
Masahiro Kitagawa and Masahito Ueda
Phys. Rev. A **47**, 5138 (1993)

Moonshot R&D Program

MOONSHOT
RESEARCH & DEVELOPMENT PROGRAM

A bold new program for creating **disruptive innovation**, decided by Plenary session of Council for Science, Technology and Innovation (“CSTI”), the Ministry of Education, Culture, Sports, Science and Technology (“MEXT”), with Japan Science and Technology Agency (“JST”) in Japan.

We will tackle **the challenges facing future society** through ambitious goal-oriented research projects, leaping beyond the limits of conventional technology **without fear of failure**.

The Moonshot Goals

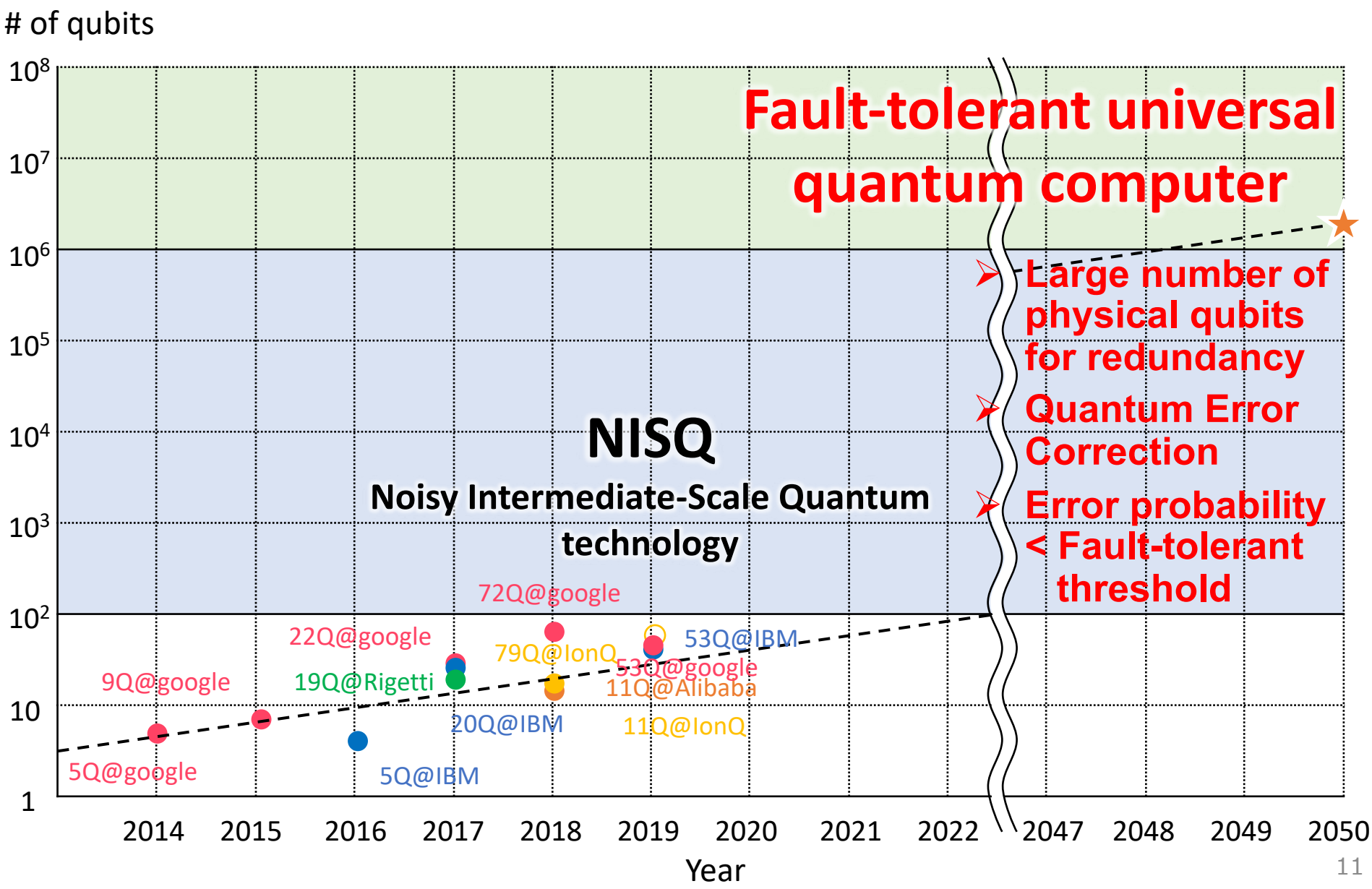
Goal 1*	Realization of a society in which human beings can be **free from limitations of body, brain, space, and time**.
Goal 2*	Realization of **ultra-early disease prediction and intervention**.
Goal 3*	Realization of **AI robots** that autonomously learn, adapt to their environment, evolve in intelligence and act alongside human beings.
Goal 4	Realization of **sustainable resource circulation** to recover the global environment.
Goal 5	Creation of the industry that enables **sustainable global food supply** by exploiting unused biological resources.
Goal 6*	Realization of a **fault-tolerant universal quantum computer** that will revolutionize economy, industry, and security.
Goal 7	Realization of sustainable care systems to **overcome major diseases by 2040**, for enjoying one's life with relief and release from health concerns until 100 years old.

* Managed by JST

Solving global social issues with QC

MOONSHOT RESEARCH & DEVELOPMENT PROGRAM
JST Japan Science and Technology Agency

Moonshot Goal 6



Key Concept of the Moonshot Goal 6

MOONSHOT RESEARCH & DEVELOPMENT PROGRAM
Japan Science and Technology Agency

2050 Realization of fault-tolerant universal quantum computers

2040 Demonstration of distributed NISQ computer &
Calculation of useful tasks under quantum error correction

2030 Development of NISQ computers of a certain scale &
Effectiveness demonstration of quantum error correction

Network

Development of quantum memory, establishment quantum interface technology between photons and quantum memory.

- Photon source & detector
- Quantum memory
- Quantum interface technology

Hardware

System design and implementation of quantum error correction, establishment of quantum bit and gate platforms.

Stage gate
Identify suitable & feasible physical system.

Super-conducting qubits	Photons	Trapped-ions	Silicon quantum dots

Software

Development of low overhead quantum error correction code and quantum algorithms, development of measurement and control software.

- Quantum error correction theory
- Middleware, compiler
- Algorithms, applications

Portfolio of the MS Goal 6

MOONSHOT RESEARCH & DEVELOPMENT PROGRAM
JST Japan Science and Technology Agency

Quantum computer hardware

Superconducting	Trapped ion	Photon	Silicon
YAMAMOTO Tsuyoshi	TAKAHASHI Hiroki	FURUSAWA Akira	MIZUNO Hiroyuki

Quantum communications

KOSAKA Hideo

YAMAMOTO Takashi

Quantum interfaces, quantum memories and quantum communications for distributed quantum computers

Theory & Software

KOASHI Masato

Quantum error collection and quantum fault-tolerance over distributed quantum computers

Project Managers

MOONSHOT RESEARCH & DEVELOPMENT PROGRAM
JST Japan Science and Technology Agency

Superconducting

Dr. YAMAMOTO Tsuyoshi

NEC Corporation

Trapped ion

Dr. TAKAHASHI Hiroki

Okinawa Institute of Science and Technology

Photon

Dr. FURUSAWA Akira

University of Tokyo

Silicon

Dr. MIZUNO Hiroyuki

Hitachi, Ltd.

Communications

Dr. KOSAKA Hideo

Yokohama National University

Communications

Dr. YAMAMOTO Takashi

Osaka University

Theory & Software

Dr. KOASHI Masato

University of Tokyo