

内閣府 第9回量子技術イノベーション会議

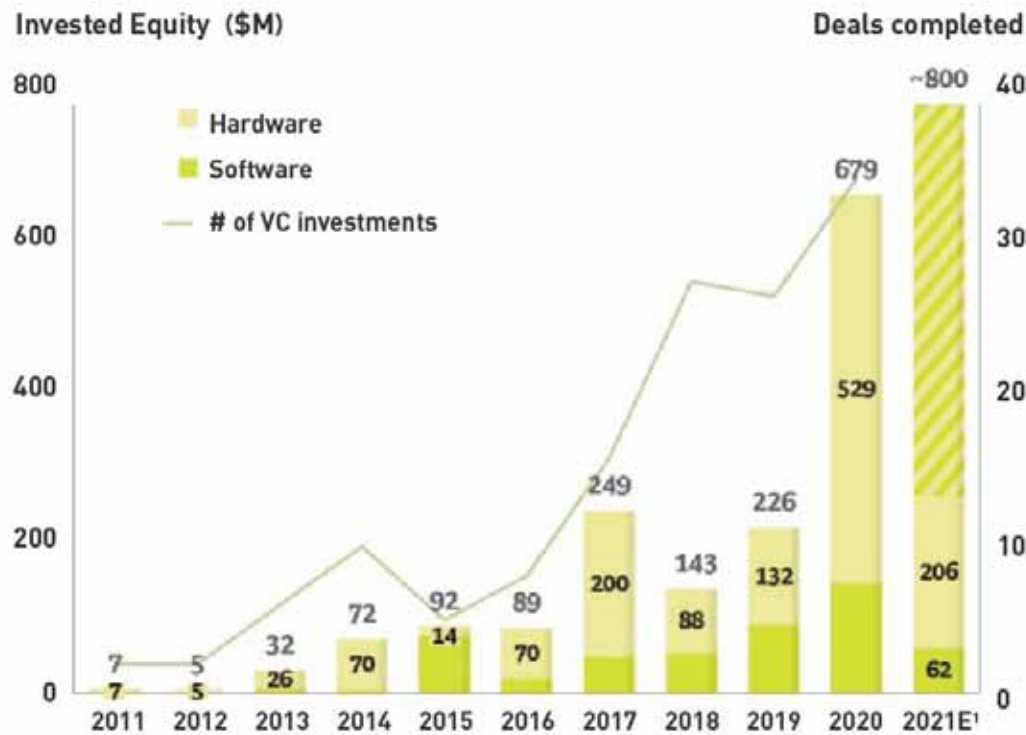
量子技術の情勢

JSR 株式会社 名誉会長

小柴 満信

市場規模と流入する市場資金

量子コンピュータへの投資額推移



2/3 Two-thirds of all equity investments (~\$1.3B) have come since 2018

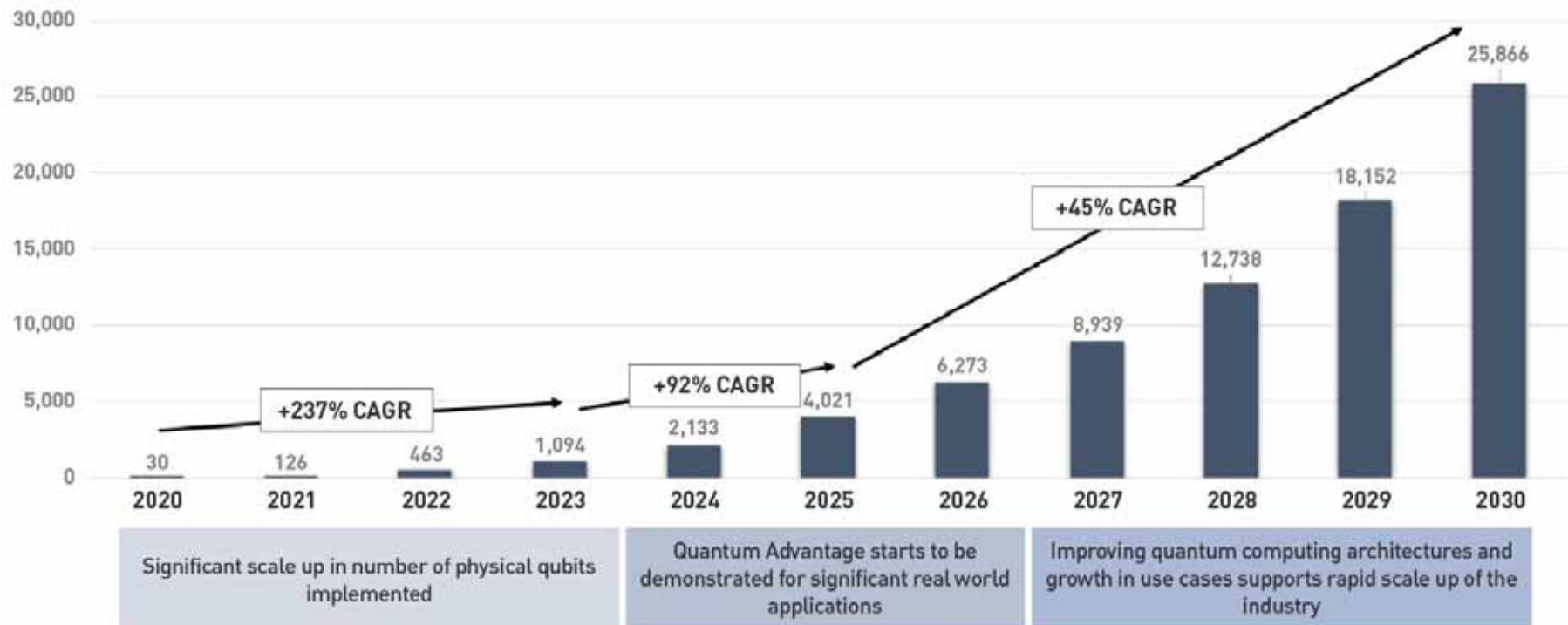
\$800M Equity investments could reach a single-year record of ~\$800M in 2021

2/3 Nearly three-fourths of investments since 2018 have been in hardware

Sources : PitchBook (as of June 7, 2021) ,BCG analysis.
¹E=estimate for full year.

Quantum Computing as a Service (QCaaS) 市場規模の推計

\$m Quantum Computing as a Service market size



量子コンピュータによるアプリケーション別の付加価値創造



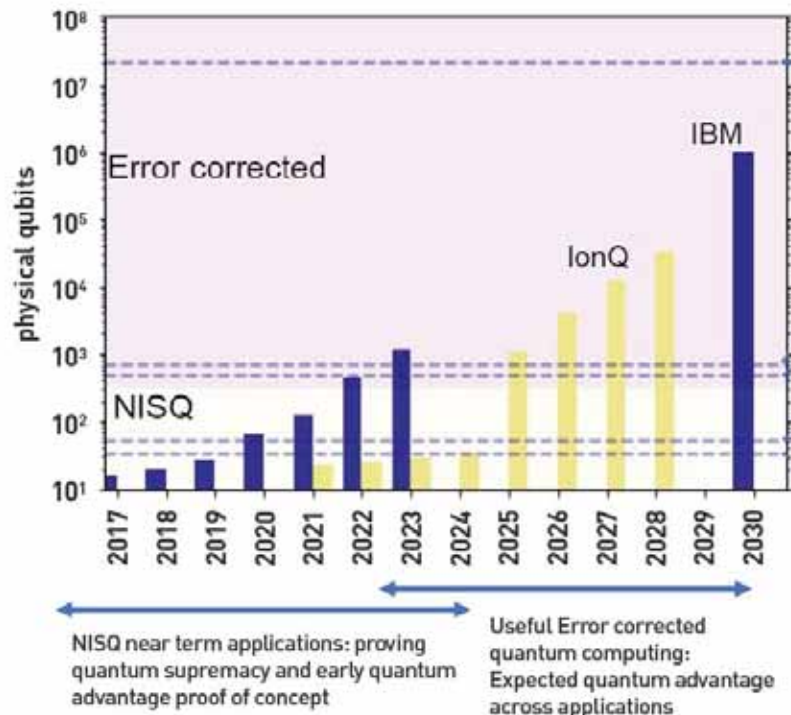
| | Applications | Value creation potential ¹ (\$B) | |
|---------------------------------|---|---|-------|
| | | Low | High |
| Cryptography (\$40-\$80B) | Encryption/decryption | \$40 | \$80 |
| Optimization (\$100-\$220B) | Aerospace: Flight route optimization | \$20 | \$50 |
| | Finance: Portfolio optimization | \$20 | \$50 |
| | Finance: Risk management | \$10 | \$20 |
| | Logistics: Vehicle routing/network optimization | \$50 | \$100 |
| Machine learning (\$150-\$220B) | Automotive: Automated vehicle, AI algorithms | \$0 | \$10 |
| | Finance: Fraud and money-laundering prevention | \$20 | \$30 |
| | High tech: Search and ads optimization | \$50 | \$100 |
| | Other: Varied AI applications | \$80+ | \$80+ |
| Simulation (\$160-\$330B) | Aerospace: Computational fluid dynamics | \$10 | \$20 |
| | Aerospace: Materials development | \$10 | \$20 |
| | Automotive: Computational fluid dynamics | \$0 | \$10 |
| | Automotive: Materials and structural design | \$10 | \$15 |
| | Chemistry: Catalyst and enzyme design | \$20 | \$50 |
| | Energy: Solar conversion | \$10 | \$30 |
| | Finance: Market simulation (e.g. derivatives pricing) | \$20 | \$35 |
| | High tech: Battery design | \$20 | \$40 |
| | Manufacturing: Materials design | \$20 | \$30 |
| | pharma: Drugs discovery and development | \$40 | \$80 |

Sources : Academic research, industry interviews, BCG analysis. ¹Represents value creation opportunity of mature technology.

量子コンピュータアプリケーションの広がり



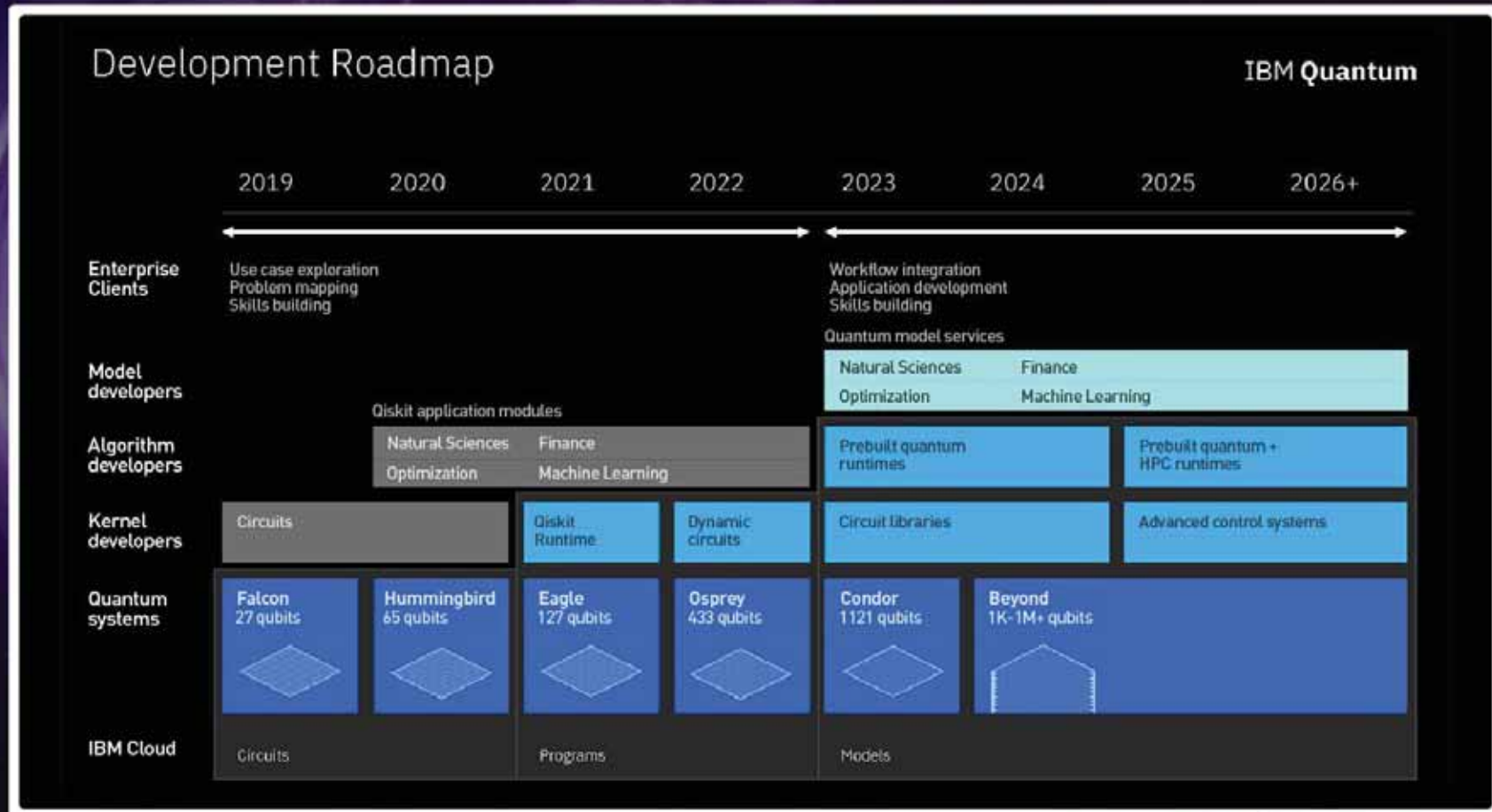
Mapping roadmaps to applications



| Algorithm | Application area |
|---|---|
| factorizing 2048 RSA (semi-prime numbers) with Shor's algorithm | Quantum encryption |
| Quantum Approximate Optimization Algorithm (QAOA) circuits | Better optimization, finance, pharmaceuticals, chemistry |
| Instantaneous Quantum Polynomial-Time (IQP) circuits | Sampling estimations, Monte Carlo type problems in finance |
| Variational quantum algorithm Amplitude or phase estimation | Optimization (small scale molecule systems in chemistry, small financial database/portfolios) |
| Hybrid quantum classical support vector machines | Quantum Machine learning |

最近の量子関係の進展

IBMのゲート型QCロードマップ



Source: IBM's roadmap for scaling quantum technology | IBM Research Blog

複製禁止

量子コンピューター上での量子化学計算



IBMの量子コンピューターを用いた高効率に発光する有機EL素子の高精度量子化学計算。
現時点では古典コンピューターでも可能な計算ではあるが、
問題設定を工夫することで、量子コンピューター実機で正しい結果が得られることを実証。
2020年の実験。2018年の実機の性能やアルゴリズムでは計算できなかった結果。
実機の性能向上や新規アルゴリズムの開発が着実に進んでいることの一つの証左。

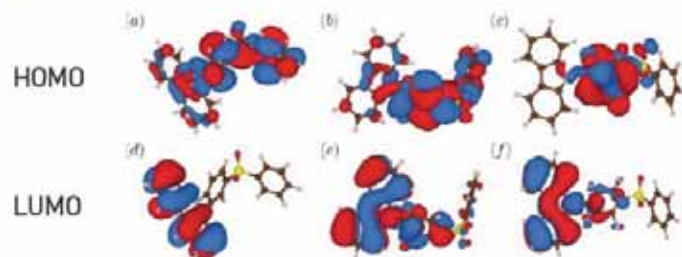
有機EL分子の励起状態と三重項状態のエネルギー差の量子計算

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npj | computational materials

Applications of quantum computing for investigations of electronic transitions in phenylsulfonyl-carbazole TADF emitters

Qi Gao^{1,2*}, Gavin O. Jones^{2,3*}, Mario Motta¹, Michihiko Sugawara¹, Hiroshi C. Watanabe¹, Takao Kobayashi¹, Eriko Watanabe^{1,2}, Yu-ya Ohnishi^{1,2}, Kojiro Nakamura^{1,2} and Kazuki Yamamoto^{1,2}



1. 三菱ケミカル 2. 慶應 3. IBM 4. JSRの共同論文

エラー緩和+状態復元により量子計算が実験の傾向をよく再現

