Useful Quantum Computing

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NASA/TP-2019-220319

Quantum Supremacy Using a Programmable Superconducting Processor

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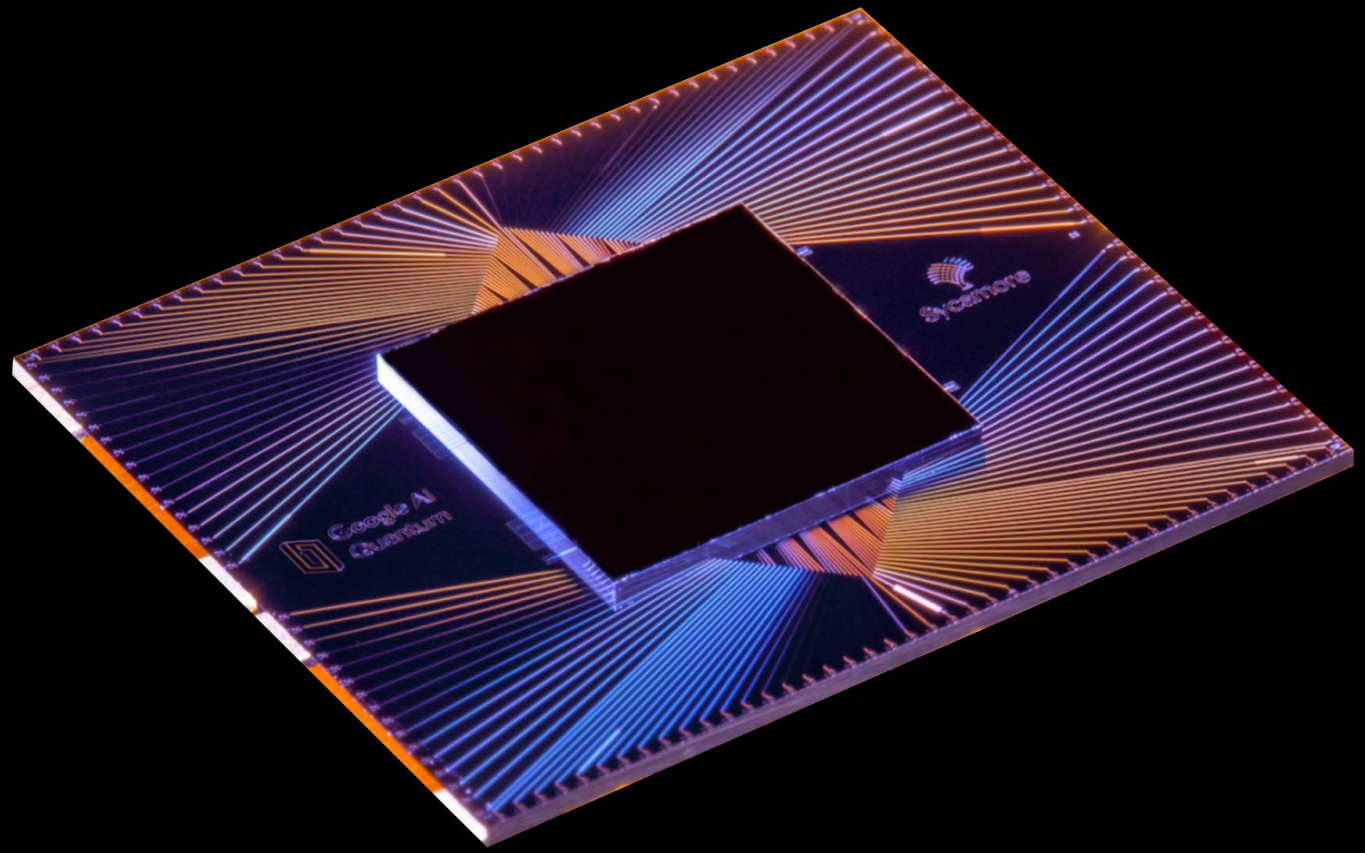
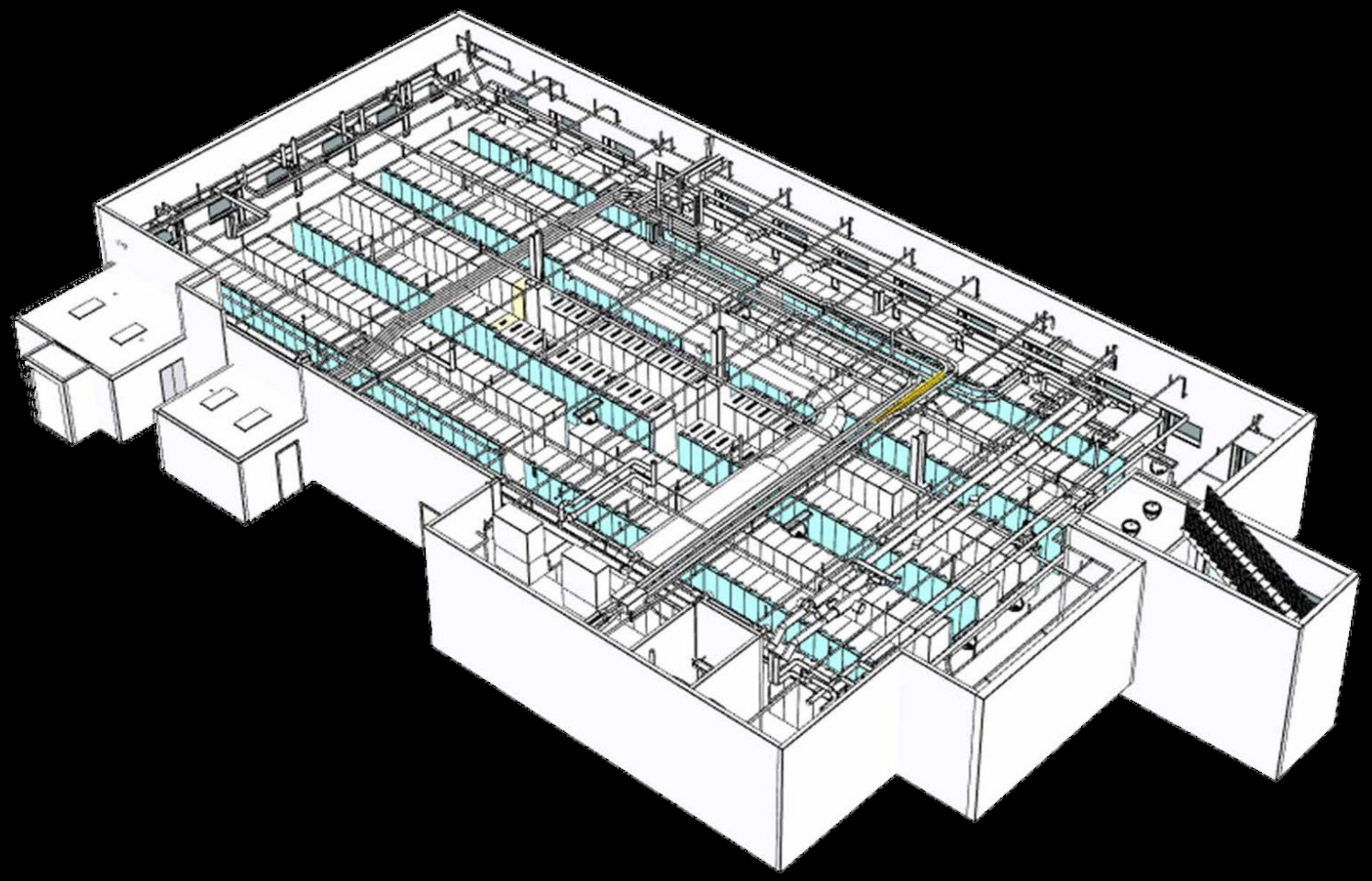
Google *Sycamore*

54 qubits × 20 clock cycles
~100 ft^2
1 million samples
200 seconds



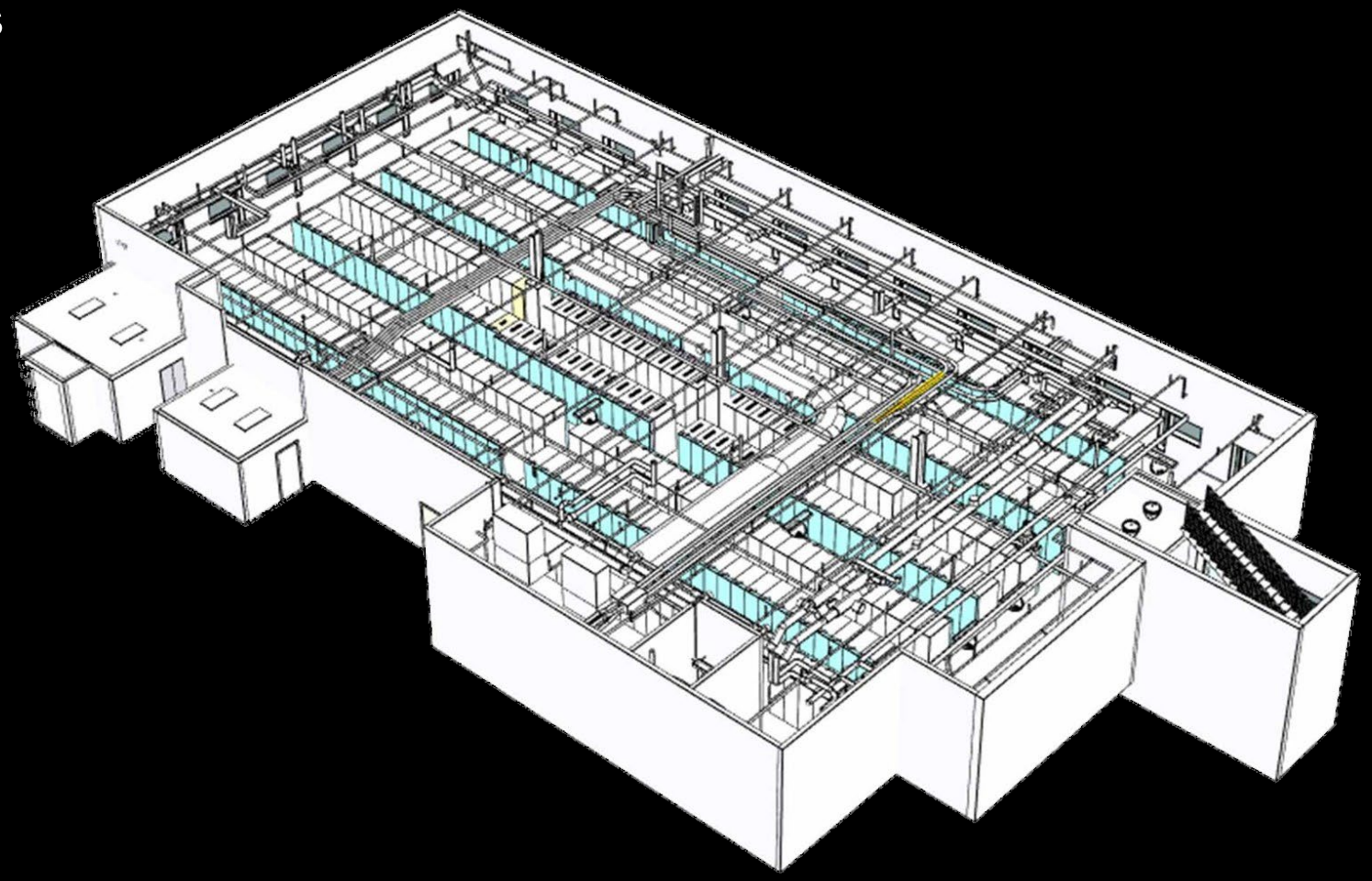
Oak Ridge *Summit* (Schrödinger-Feynman)

54 qubits × ~ 20 clock cycles
6,000 ft^2
1 million samples
10,000 years?



Oak Ridge *Summit* (Schrödinger)

54 qubits × ~20 clock cycles
6,000 ft^2
128PiB SSD
Arbitrarily many samples
6 days



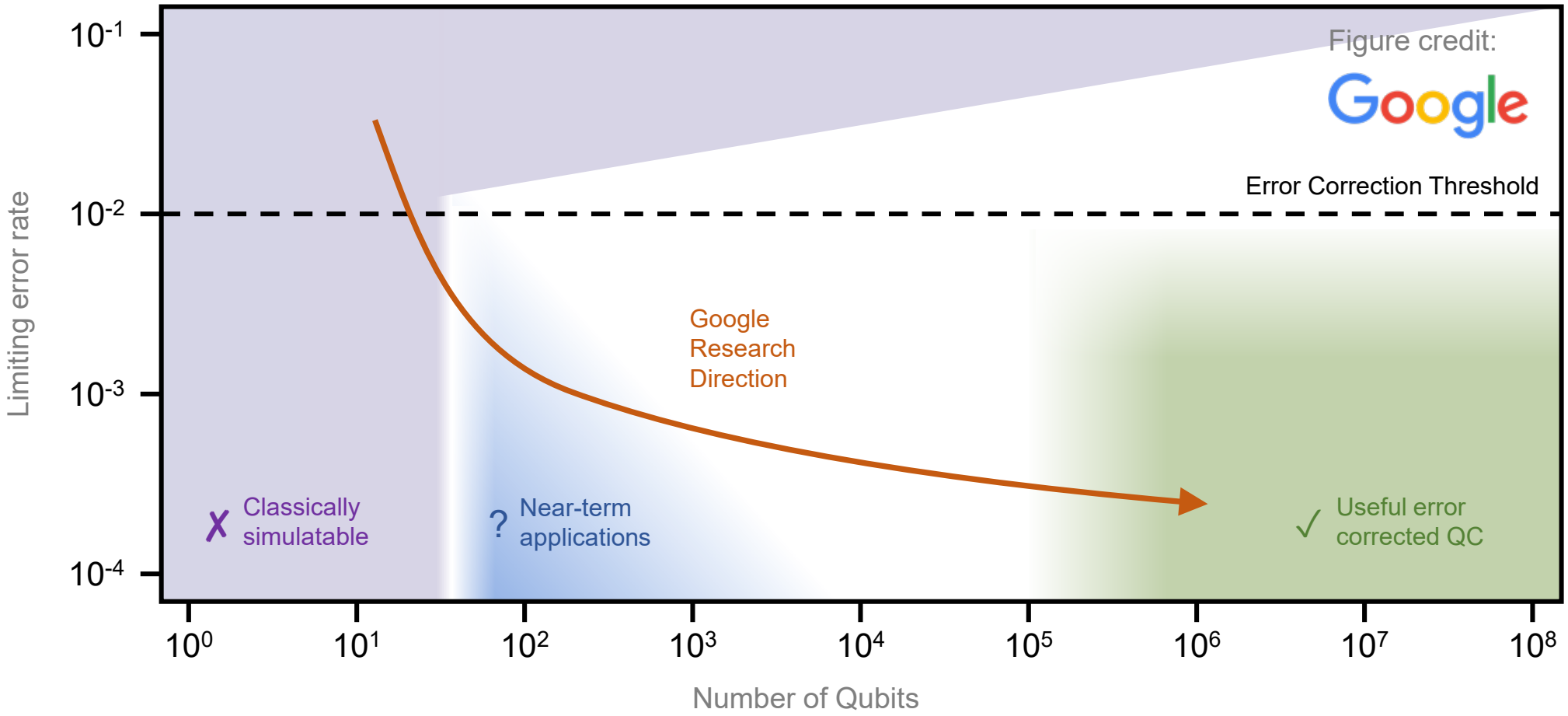
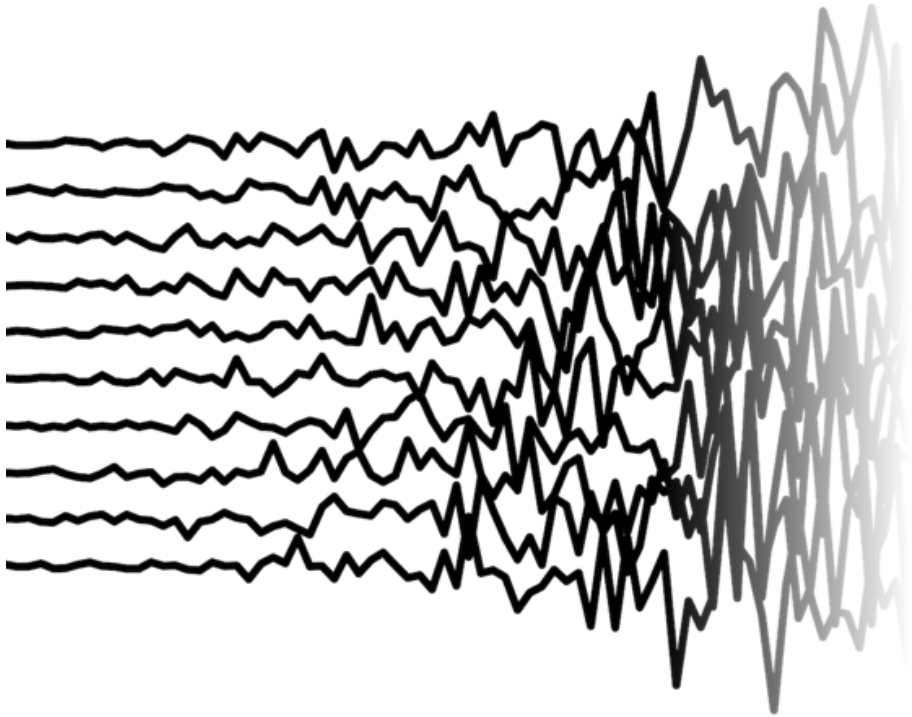
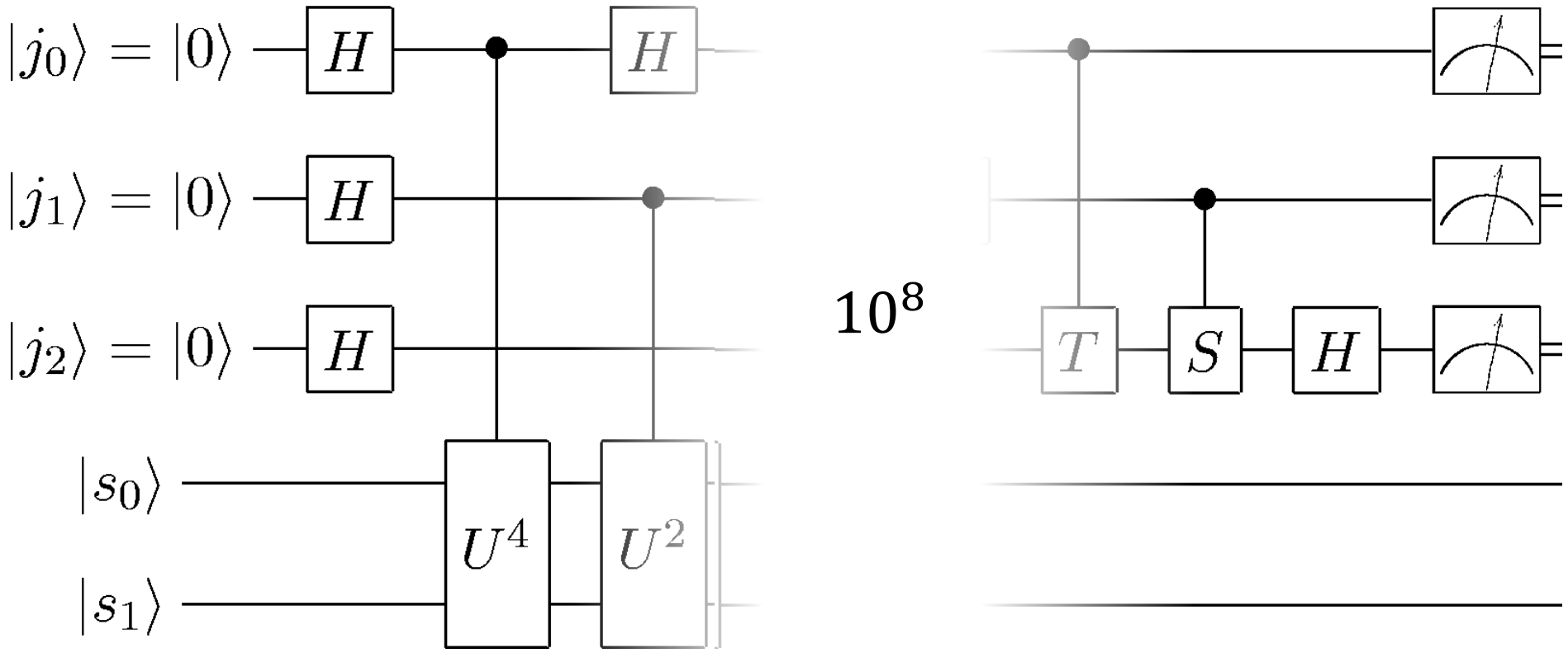
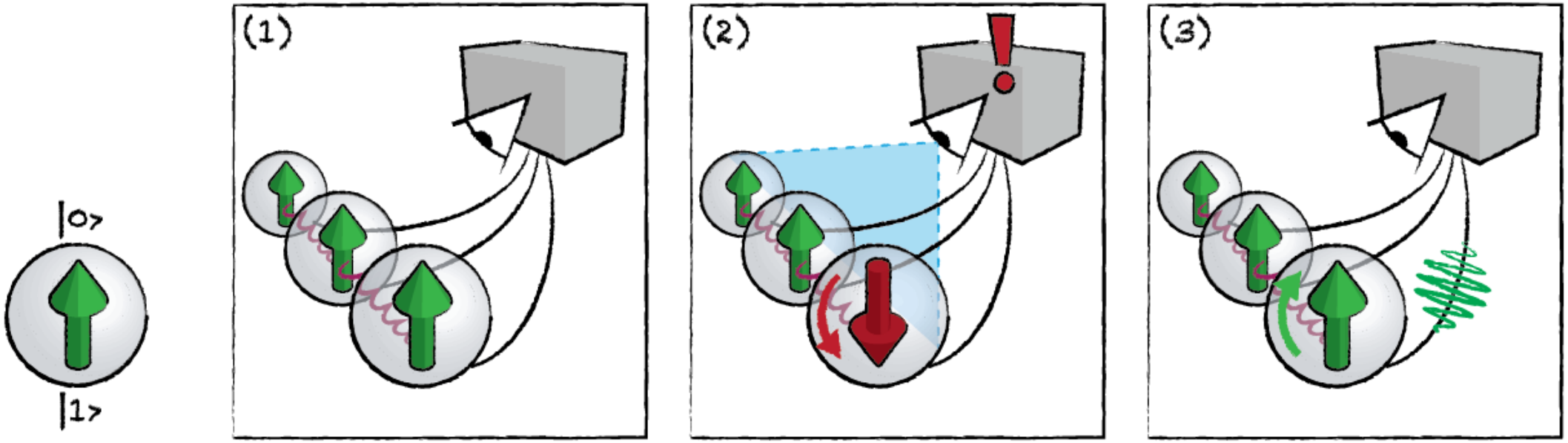


Figure credit:
Google
Error Correction Threshold
Google
Research
Direction
Classically
simulatable
Near-term
applications
Useful error
corrected QC
Limiting error rate
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
10^{5}
10^{6}
10^{7}
10^{8}
Number of Qubits




$|j_0\rangle = |0\rangle$
$|j_1\rangle = |0\rangle$
$|j_2\rangle = |0\rangle$
$|s_0\rangle$
$|s_1\rangle$
H
H
H
H
U^4
U^2
10^8
T
S
H



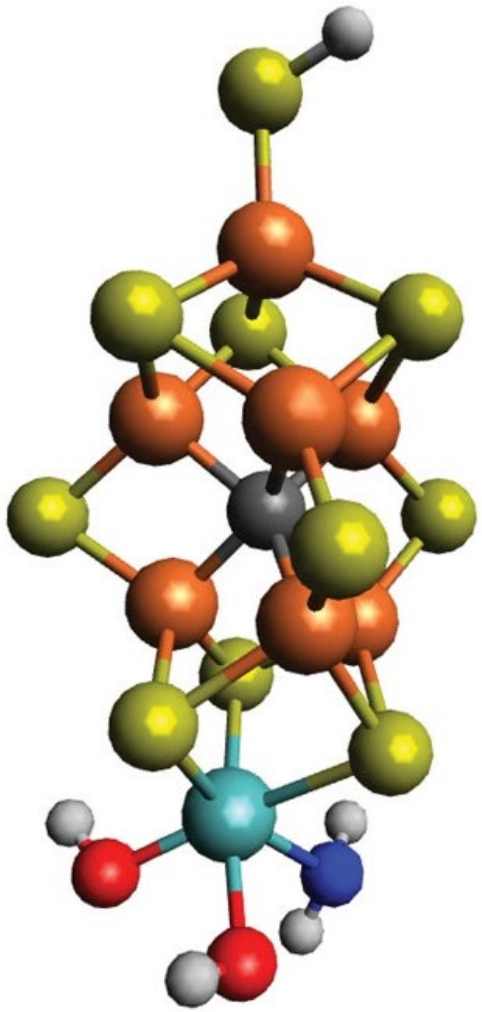
$$N_{physical} \sim 10{,}000 \times N_{logical}$$

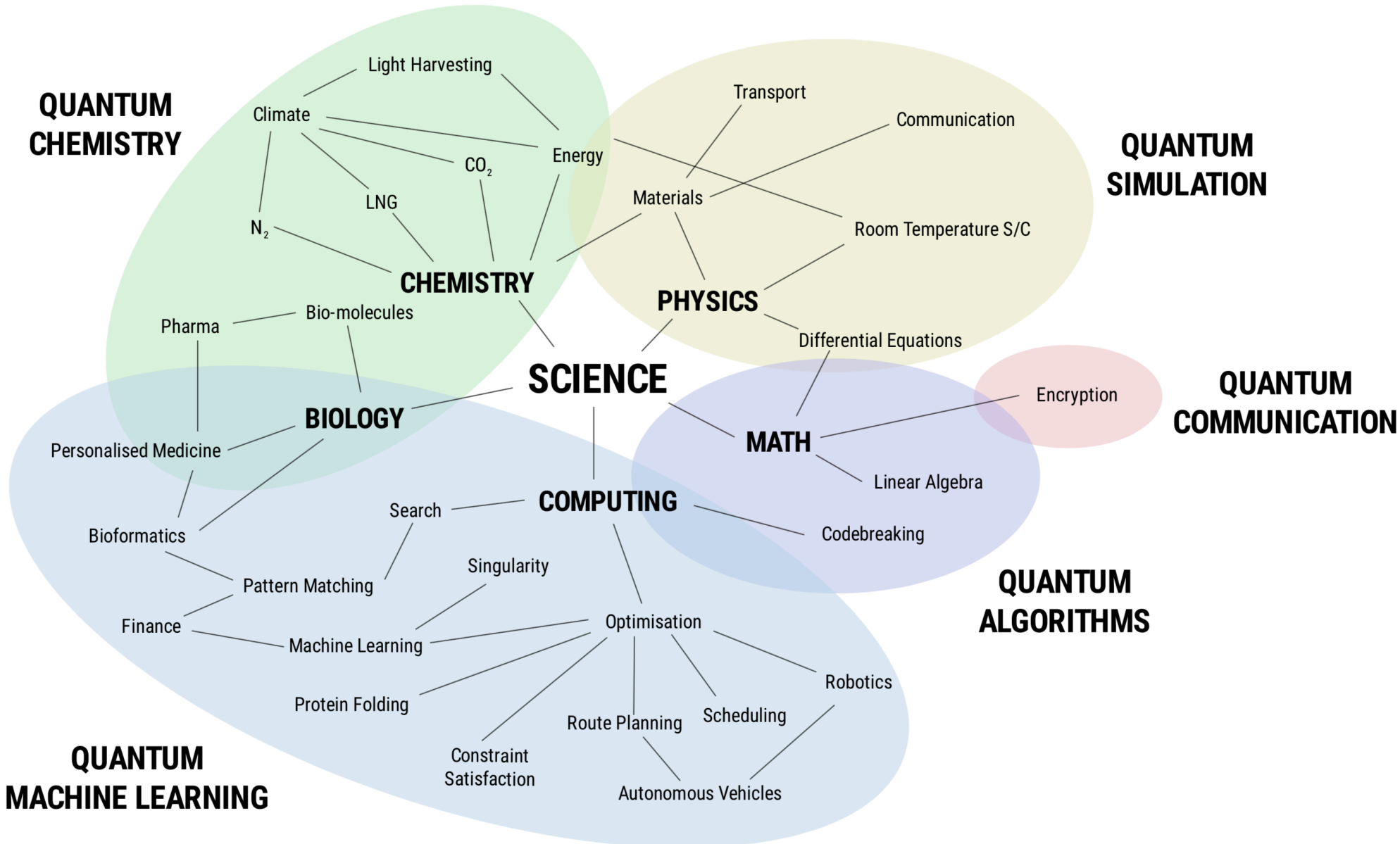
PsiQ *P1**

100 qubits × 1 million clock cycles
Few thousand ft^2
1 million physical qubits
Minutes

Oak Ridge *SuperSummit* *

100 qubits $\times$ 1 million clock cycles
$6{,}000 \times 2^{100-54} = 400{,}000{,}000{,}000{,}000{,}000$ ft^2
$128 \times 2^{100-54} = 9{,}000{,}000{,}000{,}000{,}000$ PiB SSD
A very long time




QUANTUM CHEMISTRY
Light Harvesting
Climate
Energy
CO_2
LNG
N_2
CHEMISTRY
Pharma
Bio-molecules
BIOLOGY
Personalised Medicine
Bioformatics
Transport
Communication
Materials
Room Temperature S/C
PHYSICS
Differential Equations
QUANTUM SIMULATION
SCIENCE
Encryption
QUANTUM COMMUNICATION
MATH
Linear Algebra
COMPUTING
Search
Codebreaking
Singularity
Pattern Matching
Finance
Optimisation
Machine Learning
Robotics
Protein Folding
Route Planning
Scheduling
Constraint Satisfaction
Autonomous Vehicles
QUANTUM ALGORITHMS
QUANTUM MACHINE LEARNING

❄ □

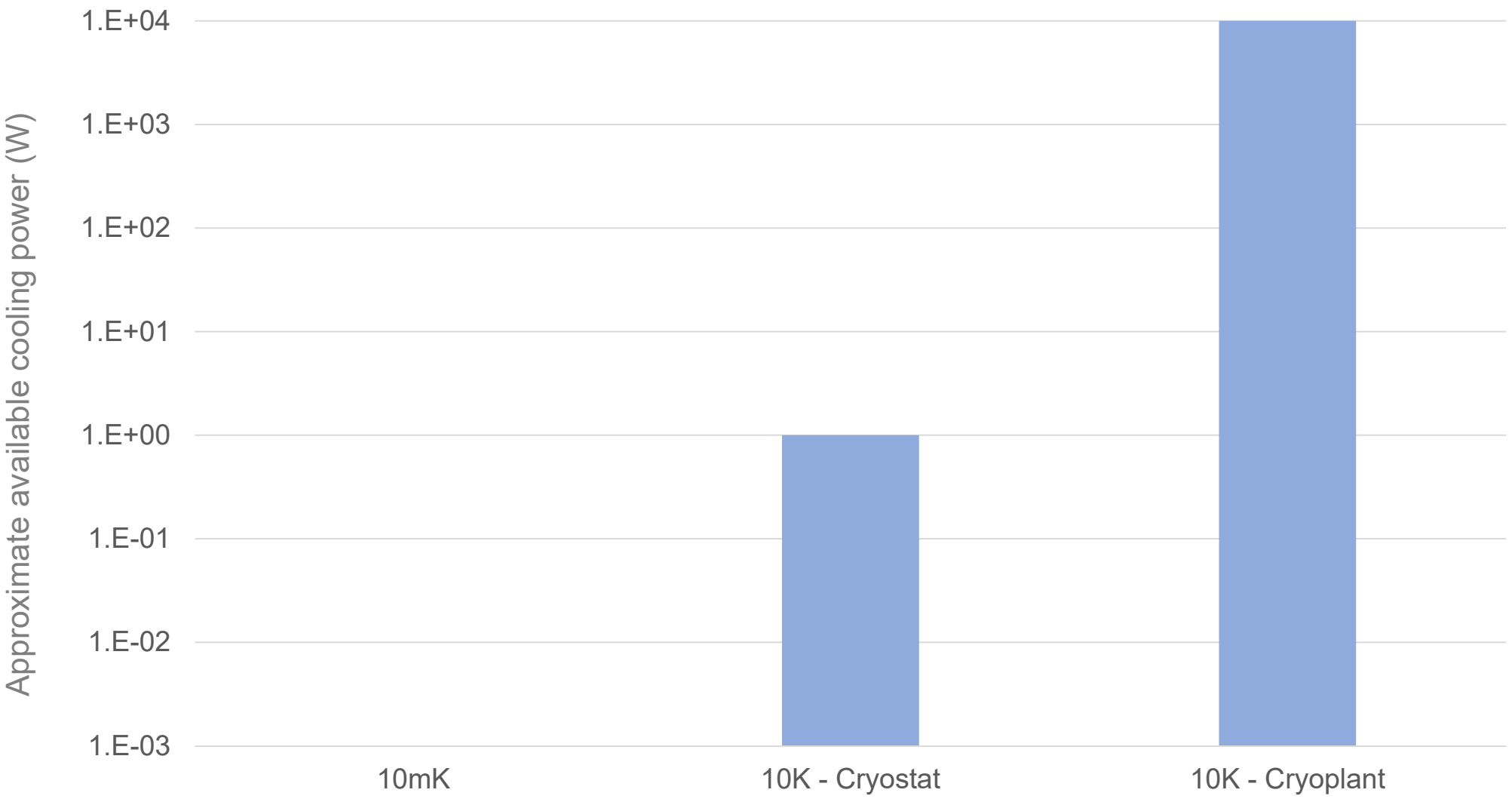
Cooling power

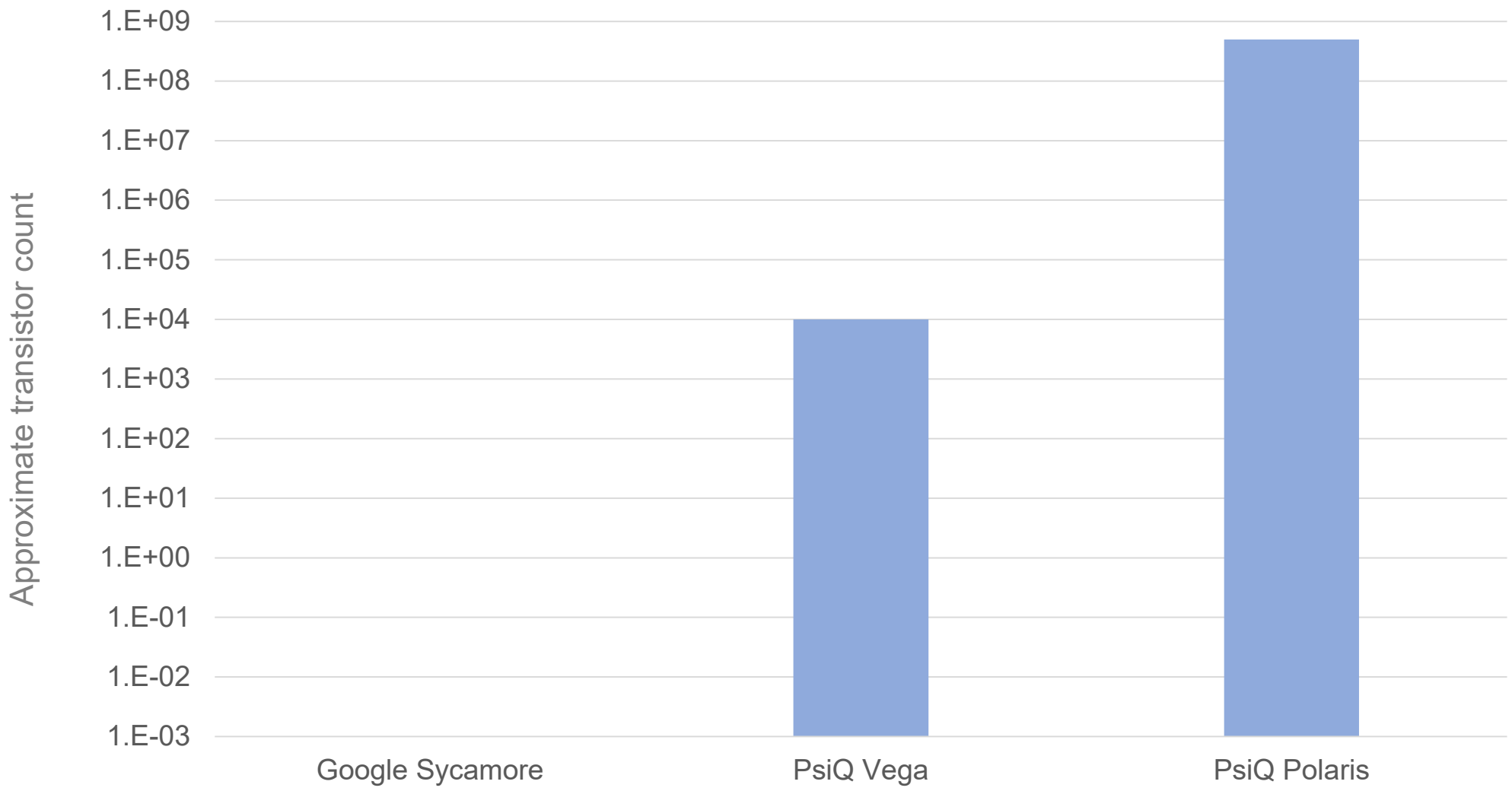
⚡□

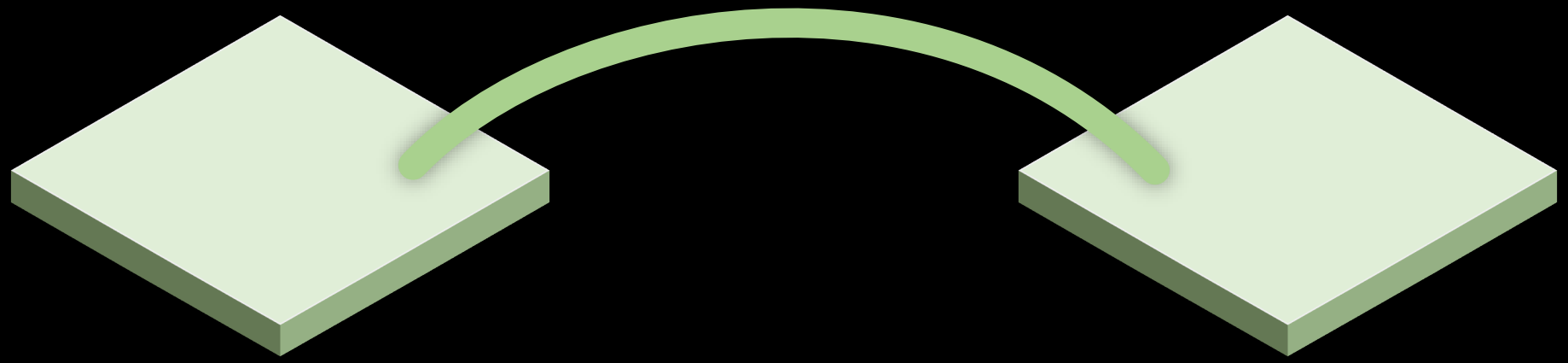
Control electronics

Connectivity

Manufacturability


Approximate available cooling power (W)
1.E+04
1.E+03
1.E+02
1.E+01
1.E+00
1.E-01
1.E-02
1.E-03
10mK
10K - Cryostat
10K - Cryoplant


Approximate transistor count
1.E+09
1.E+08
1.E+07
1.E+06
1.E+05
1.E+04
1.E+03
1.E+02
1.E+01
1.E+00
1.E-01
1.E-02
1.E-03
Google Sycamore
PsiQ Vega
PsiQ Polaris




067
067
136
229
166