PASQAL

QUANTUM DISCOVERY

Hardware platforms

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Building quantum computers

DiVincenzo's criteria

According to physicist David DiVincenzo, constructing a quantum computer requires that the experimental setup meet five criteria:

I. A scalable physical system with well characterized qubits

II. The ability to initialize the state of the qubits

III. A qubit-specific measurement capability

IV. A universal set of quantum gates

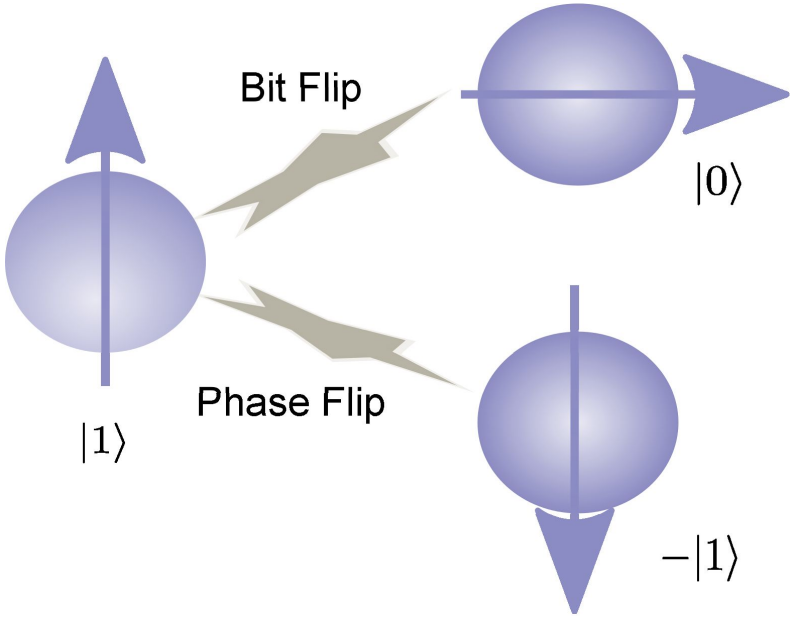
V. Long relevant decoherence time

Building quantum computers

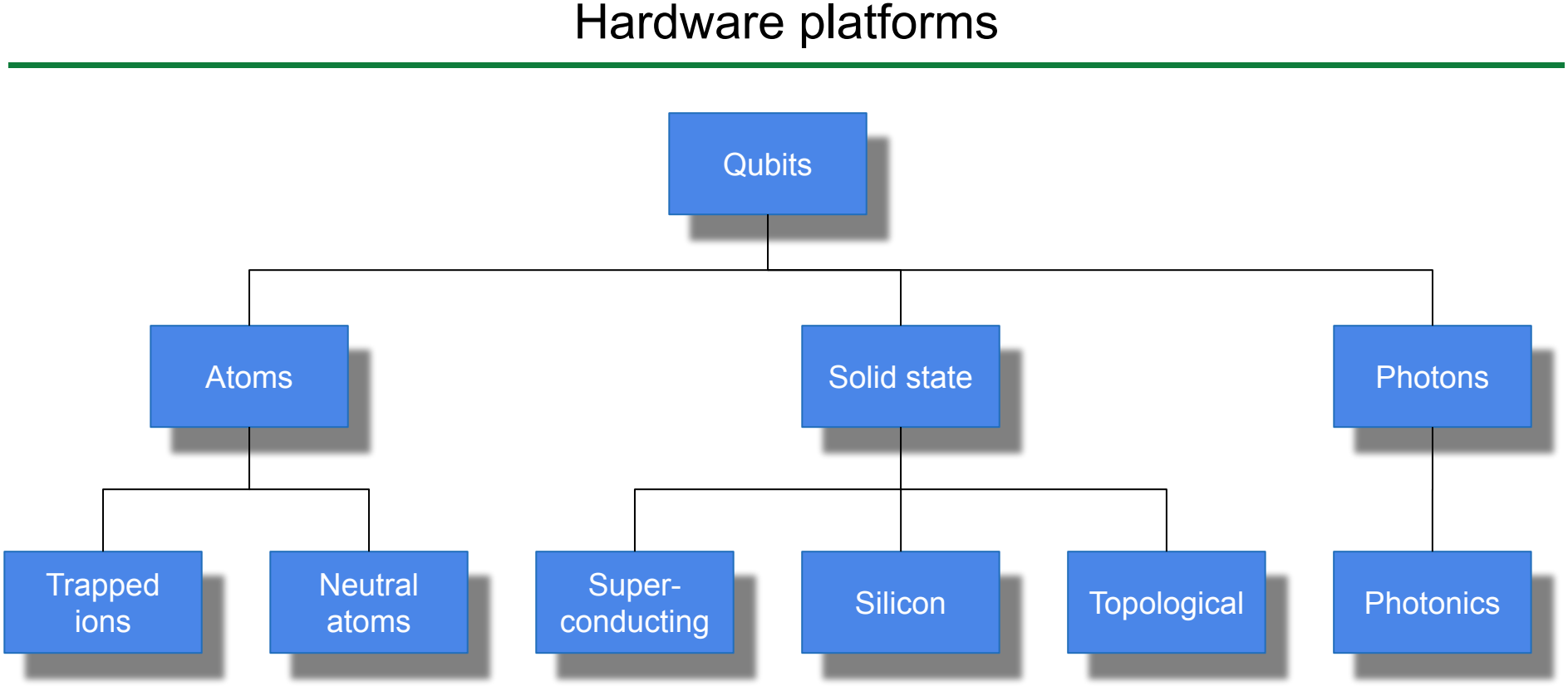
Decoherence effects

Exposure to heat and radiations make qubits prone to errors:

- **Bit flip channel:** invert the probability amplitudes of a qubit (0 → 1, 1 → 0)
- **Phase flip channel:** invert the phase of a qubit (0 → 0, 1 → -1)
- **Depolarizing channel:** turn a qubit to a classical bit 0 or 1
- …

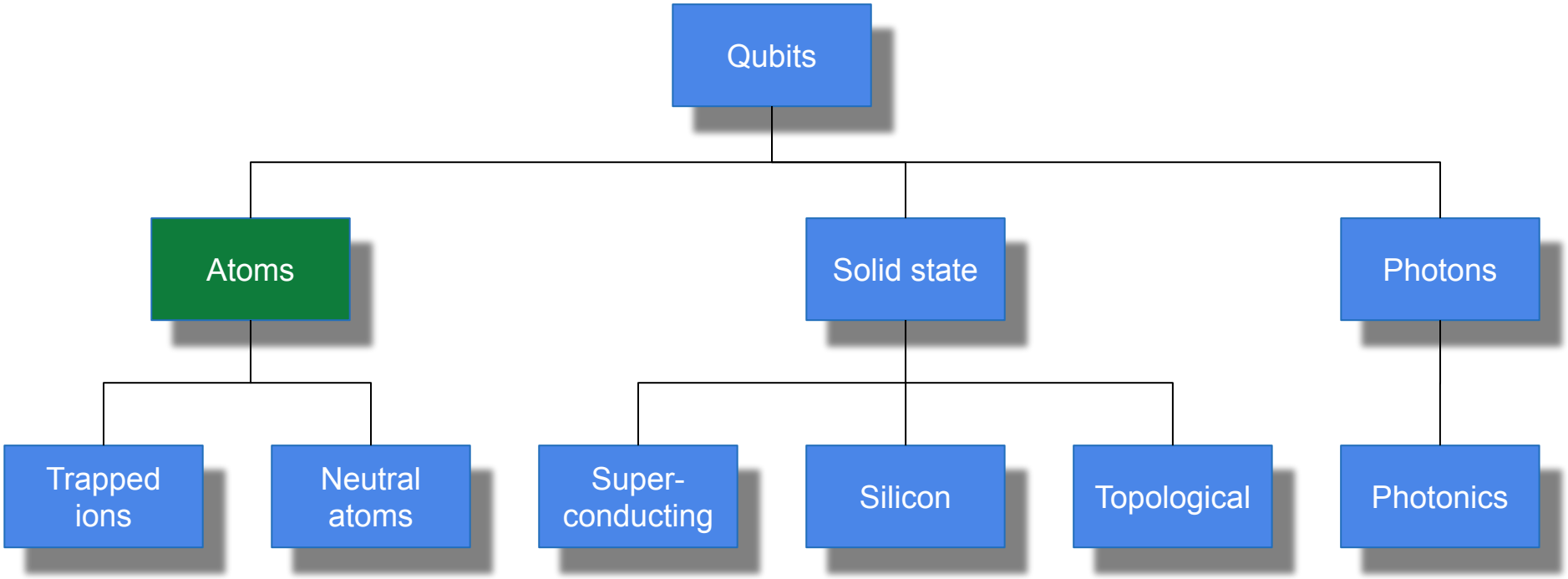


Qubit platforms



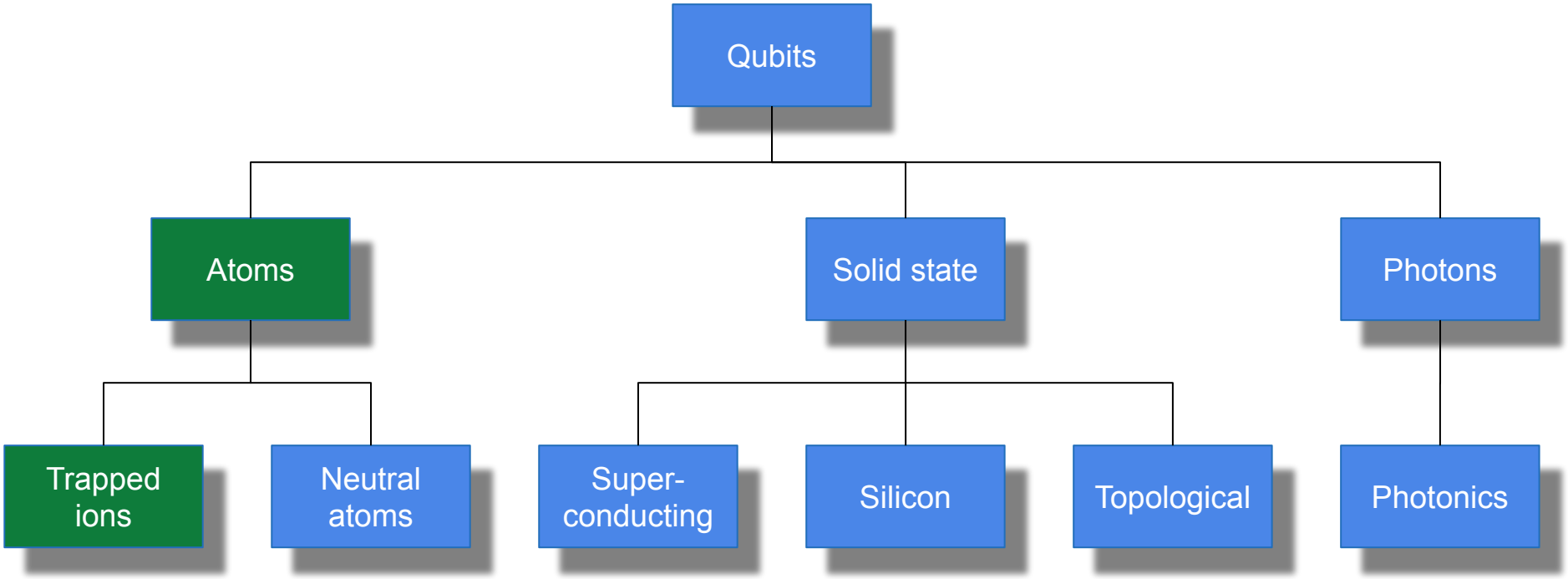
Qubit platforms

Atomic devices



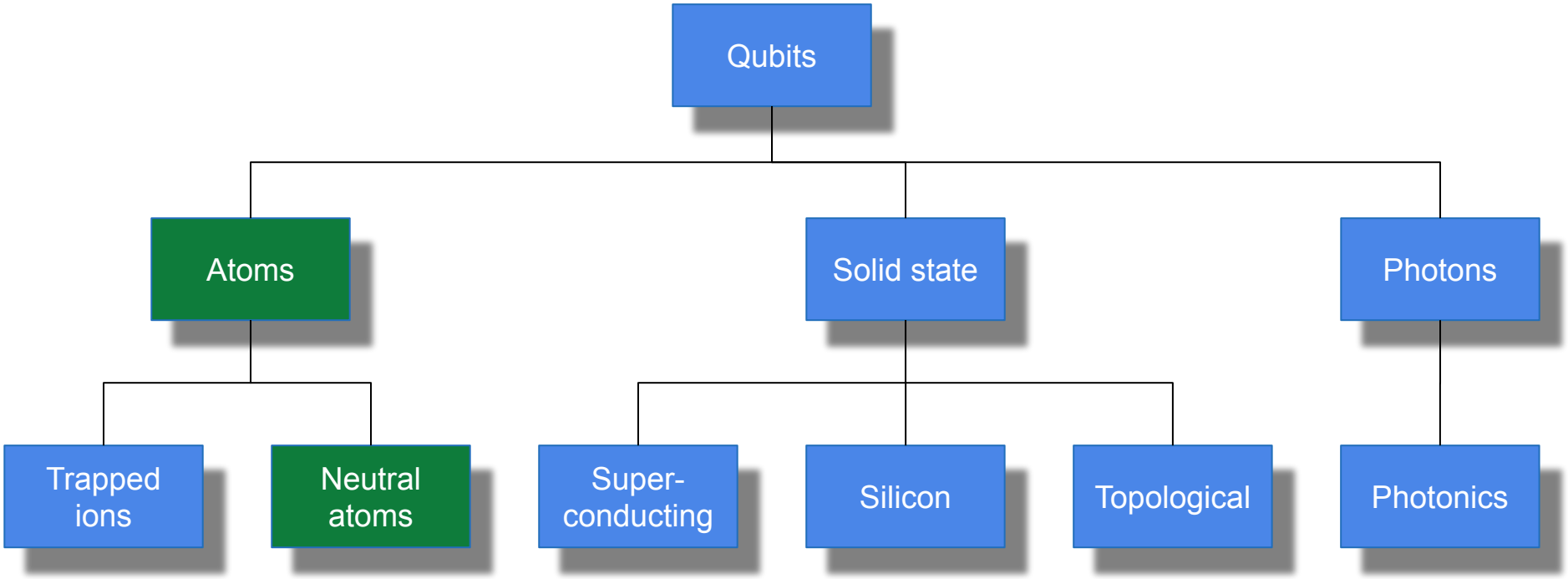
Qubit platforms

Trapped ion qubits



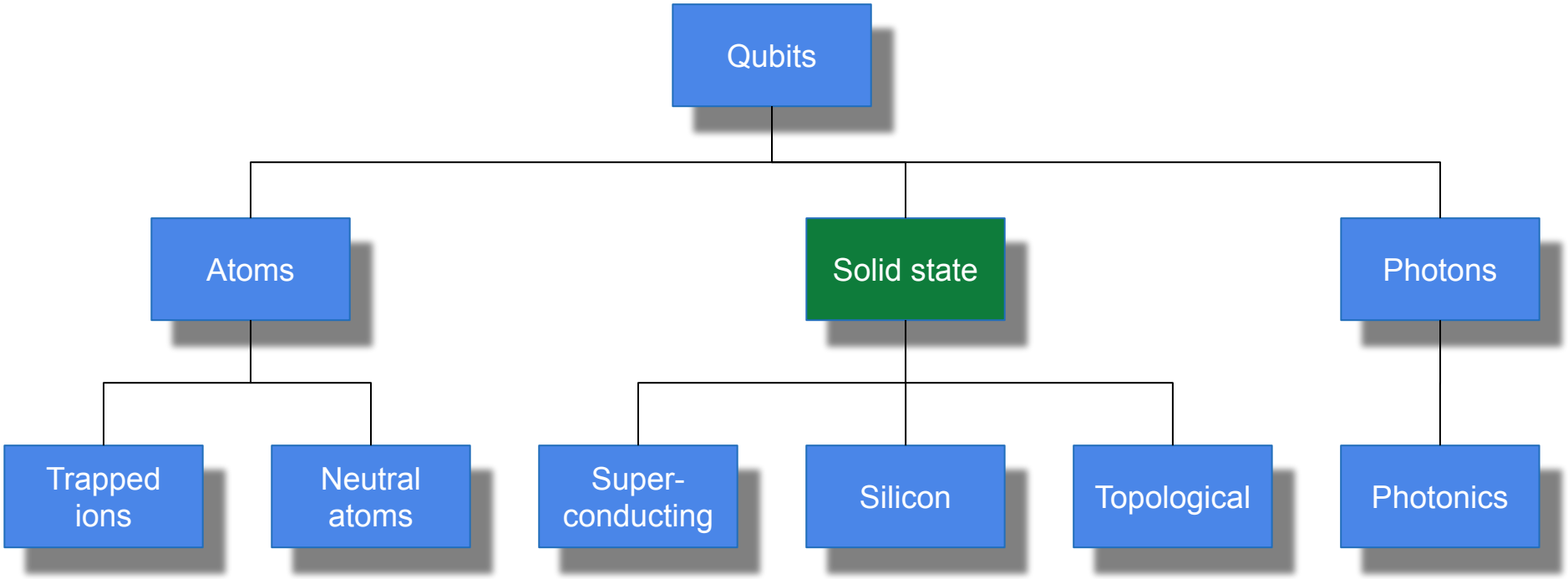
Qubit platforms

Neutral atom qubits



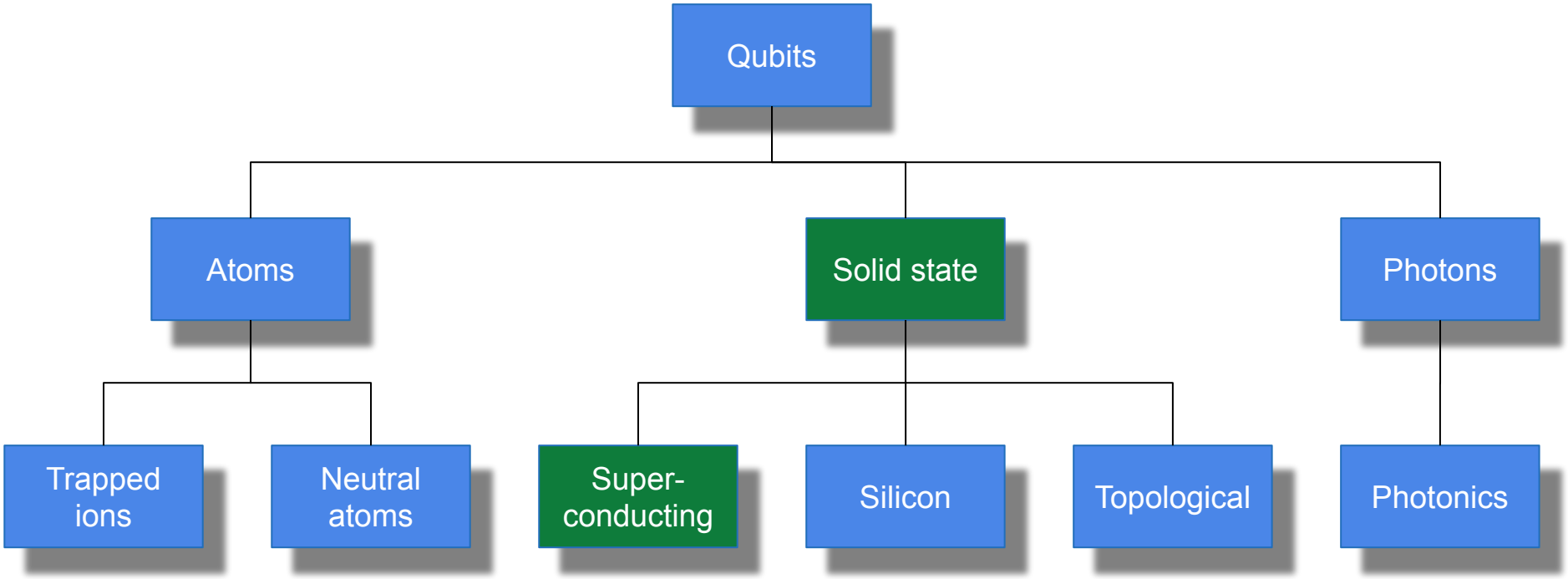
Qubit platforms

Solid state devices



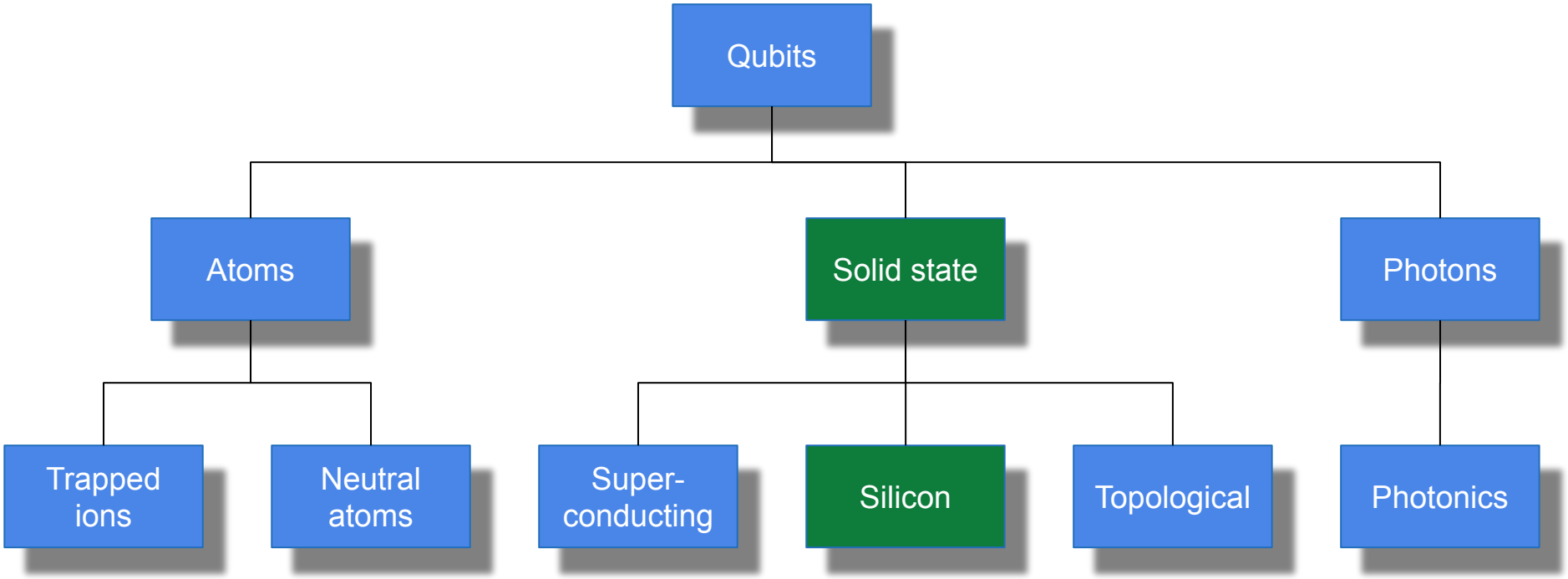
Qubit platforms

Superconducting qubits



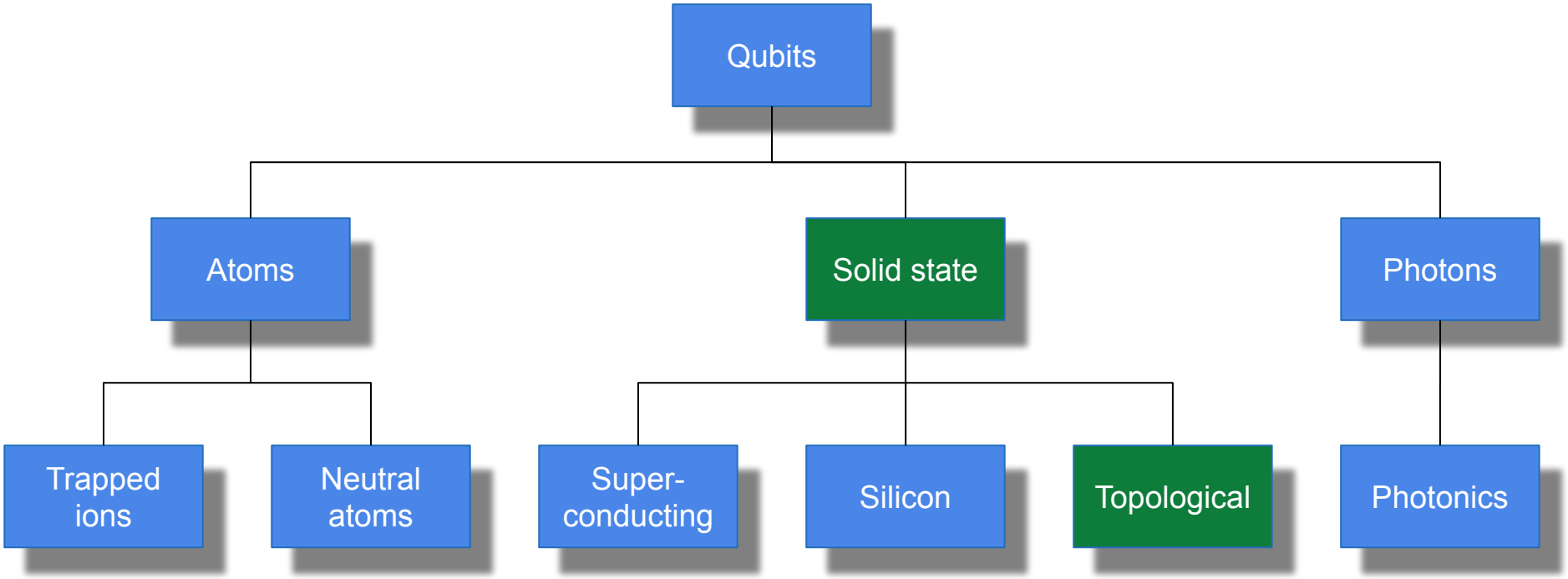
Qubit platforms

Silicon qubits



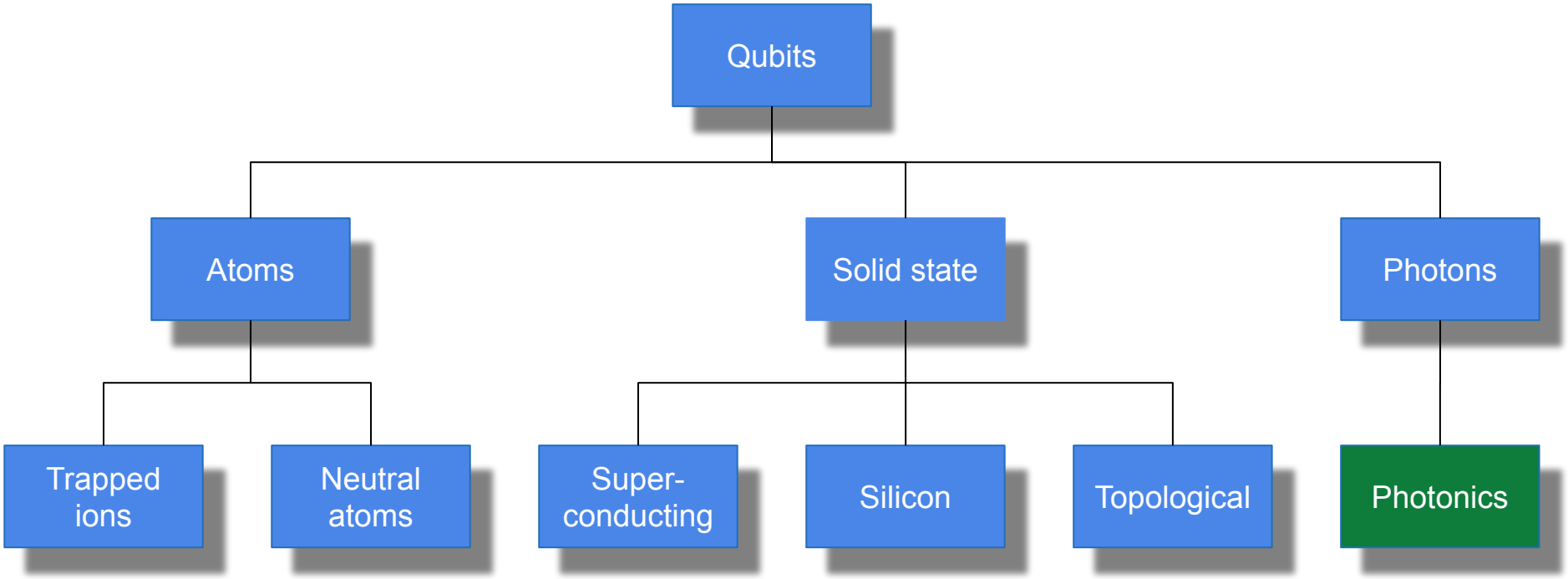
Qubit platforms

Topological qubits



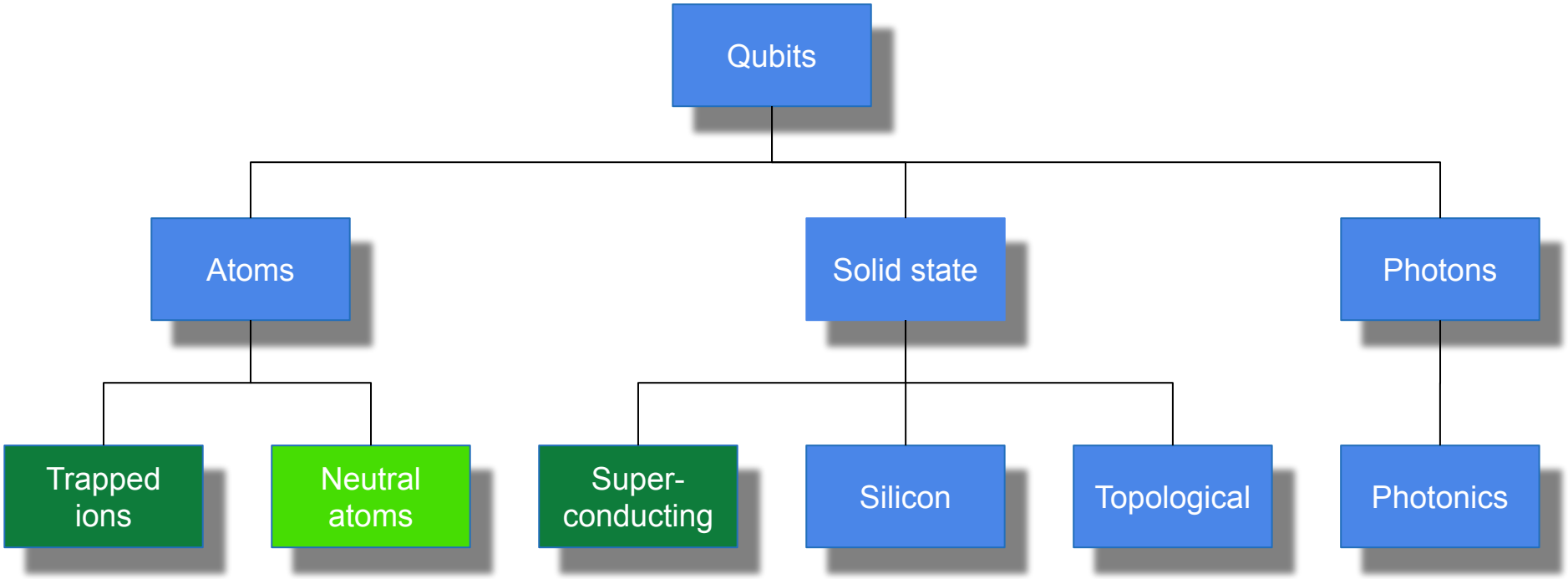
Qubit platforms

Photonic qubits



Leading qubit platforms

Atoms vs Solid state devices



Leading qubit platforms

Superconducting qubits

- ✗ Coherence time
- ✗ Gate fidelities
- ✗ Nearest neighbours connectivity
- ✗ Artificial systems
- ✗ Digital quantum computing only
- ✓ Gate time
- ✗ Near absolute zero operation

Neutral atom qubits

- ✓ Coherence time
- ✓ Gate fidelities
- ✓ Extended connectivity
- ✓ Natural systems
- ✓ Digital / Analog quantum computing
- ✗ Gate time
- ✗ Vacuum operation

Conclusion

- ➔ Performance benchmarks for quantum computers include: coherence time, gate fidelity, gate time, ability to scale, universality of operations, *etc*
- ➔ Atoms, ions, photons and electrons can be used as quantum information carriers
- ➔ Neutral atom arrays where information is encoded in selected electronic energy levels of Rubidium atoms is PASQAL's technology of choice
- ➔ Neutral atoms offer digital and analog computing capabilities, long range connectivity, and the ability to reshape the processor architecture on every run
- ➔ We are in the early age of quantum computing, so the race to quantum advantage will be long