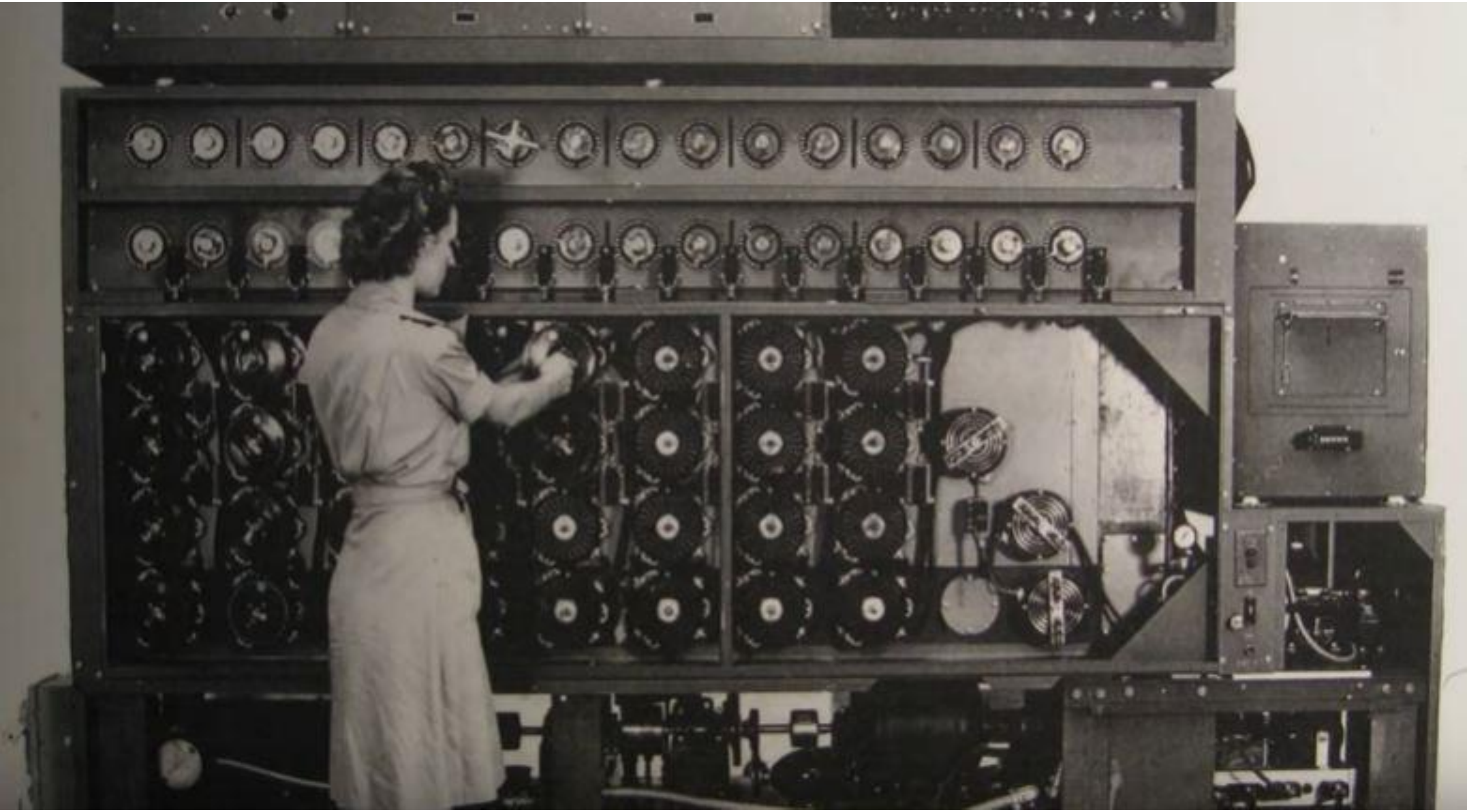
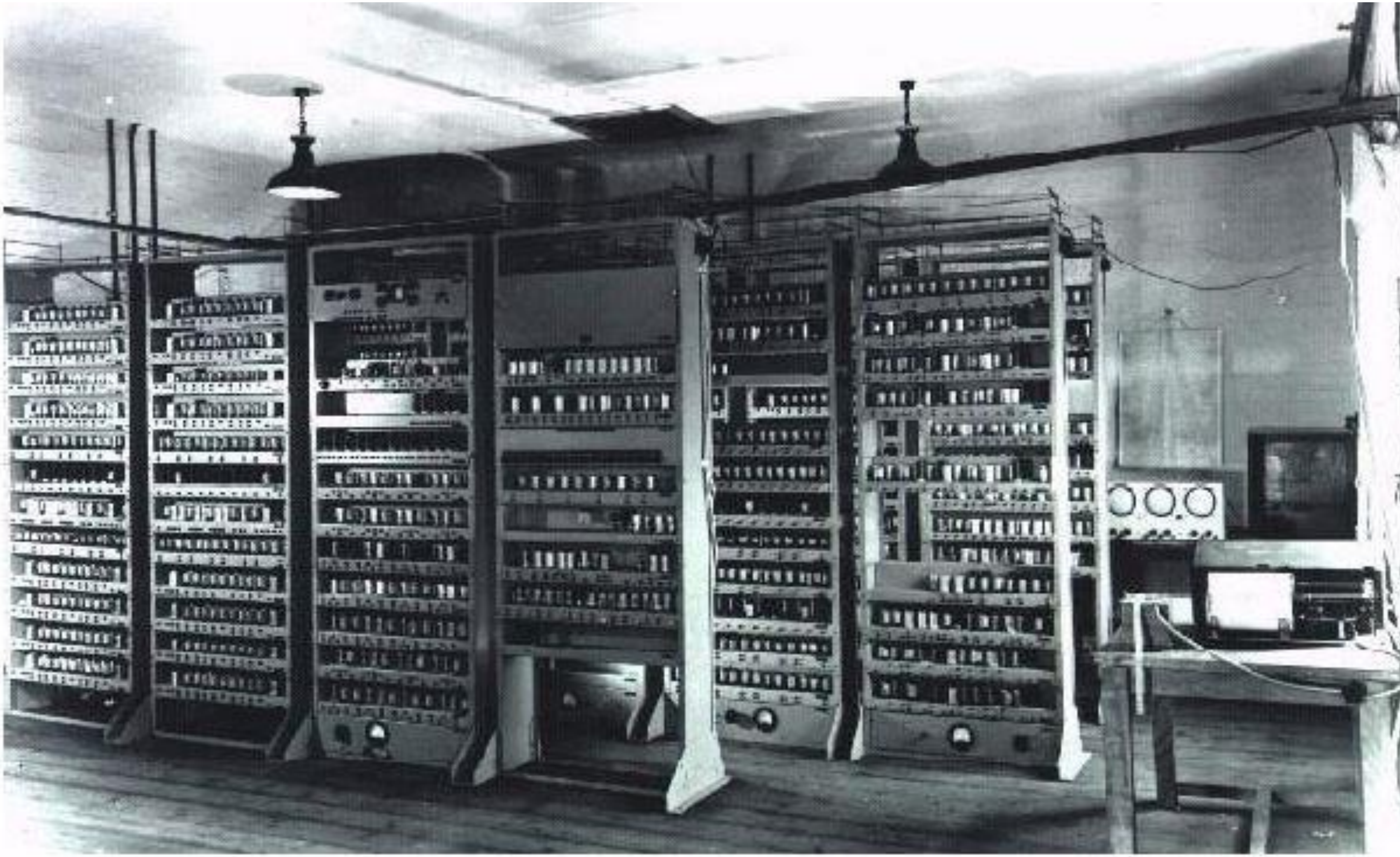
Computer történelem 1943-2019

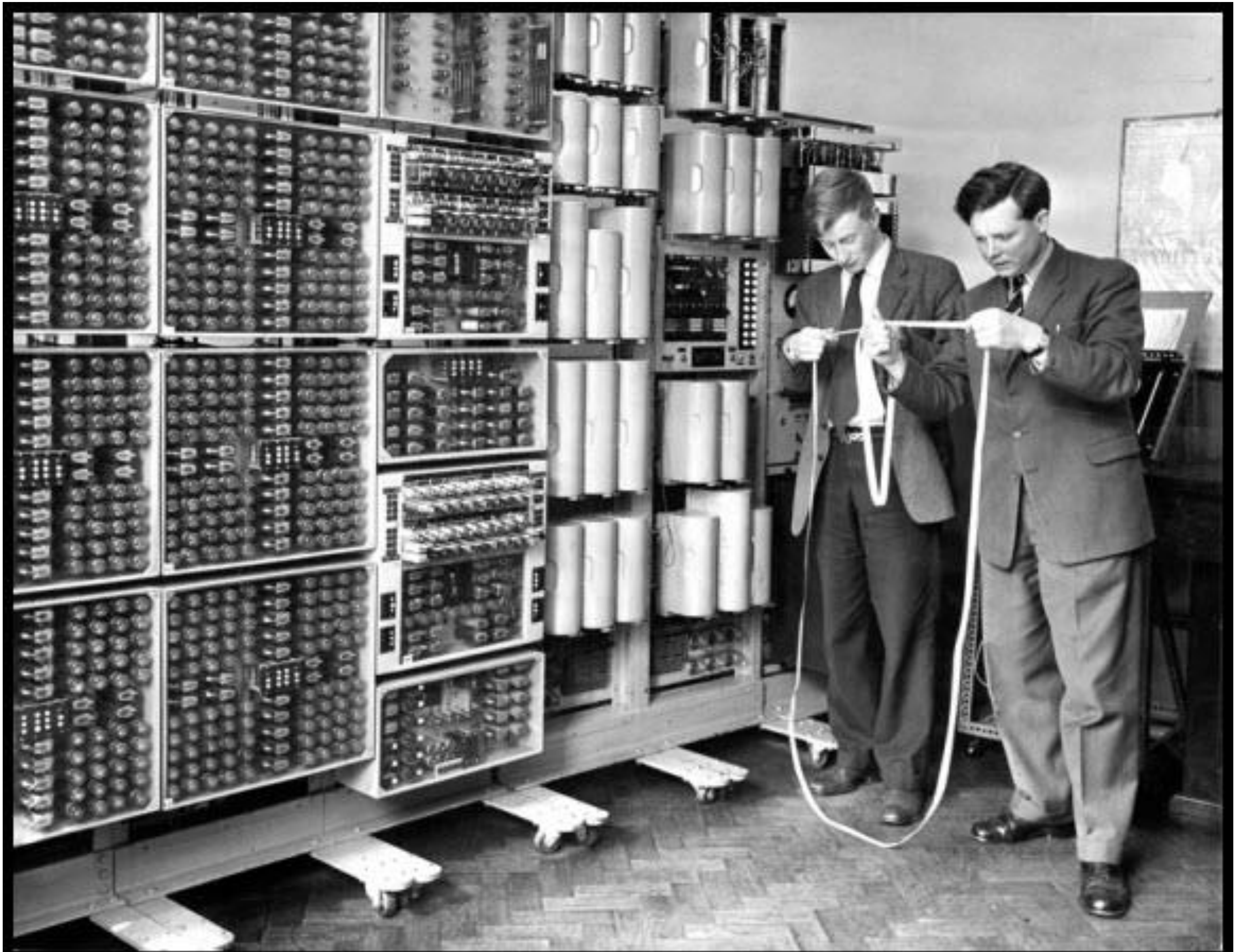


Alan Turing's mechanical computer used to break the Enigma code during WWII

"I think there can be a world market for maybe five computers" — Thomas Watson, CEO of IBM, 1943



EDSAC (1949) was the size of a room but could perform 650 instructions per second. University of Cambridge

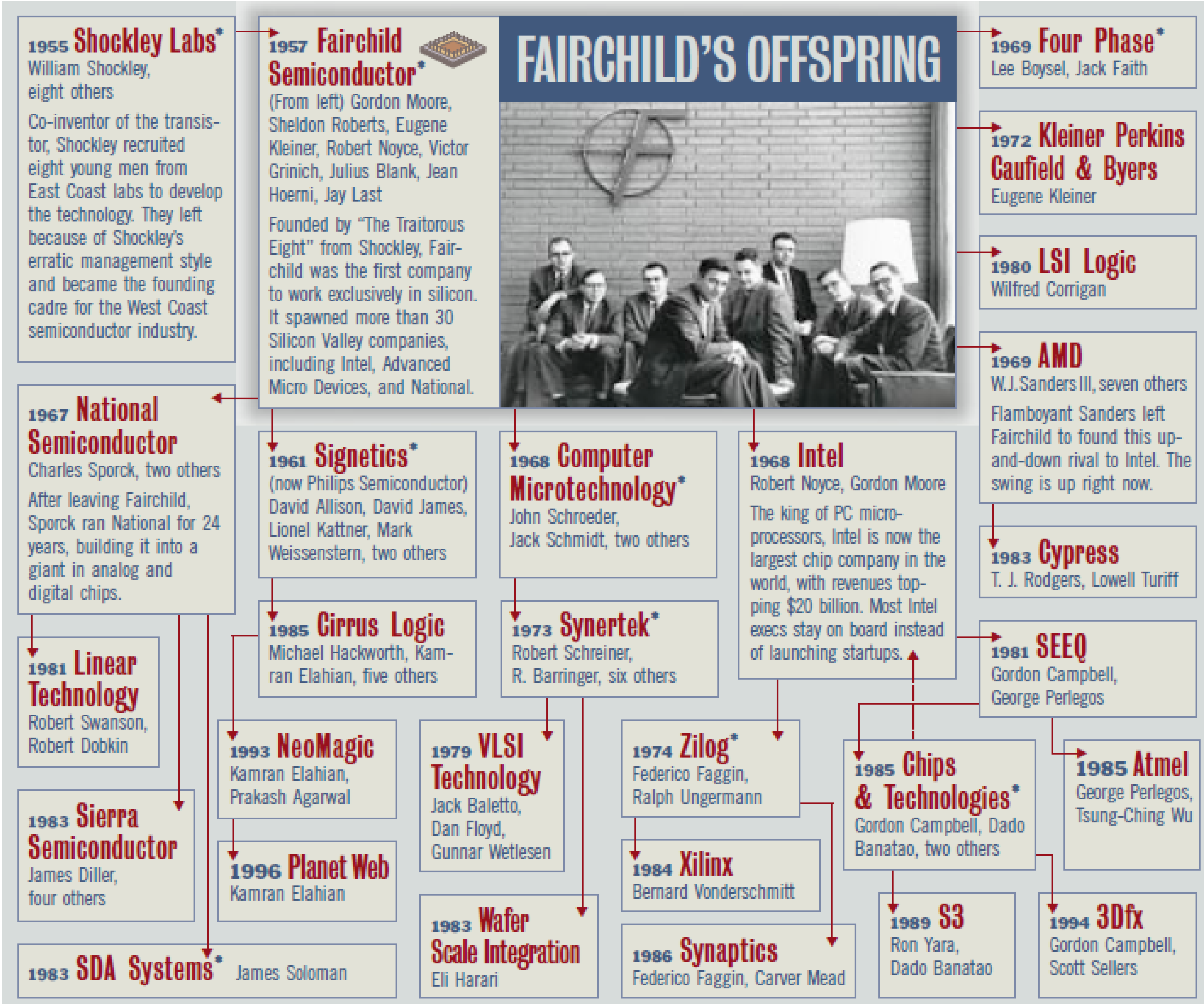


In 1947, William Shockley led a Palo Alto-based team at Bell Labs that invented the world's first amplifying semiconductor, the transistor. They won a Nobel Prize in physics.

Jönnek az oroszok…

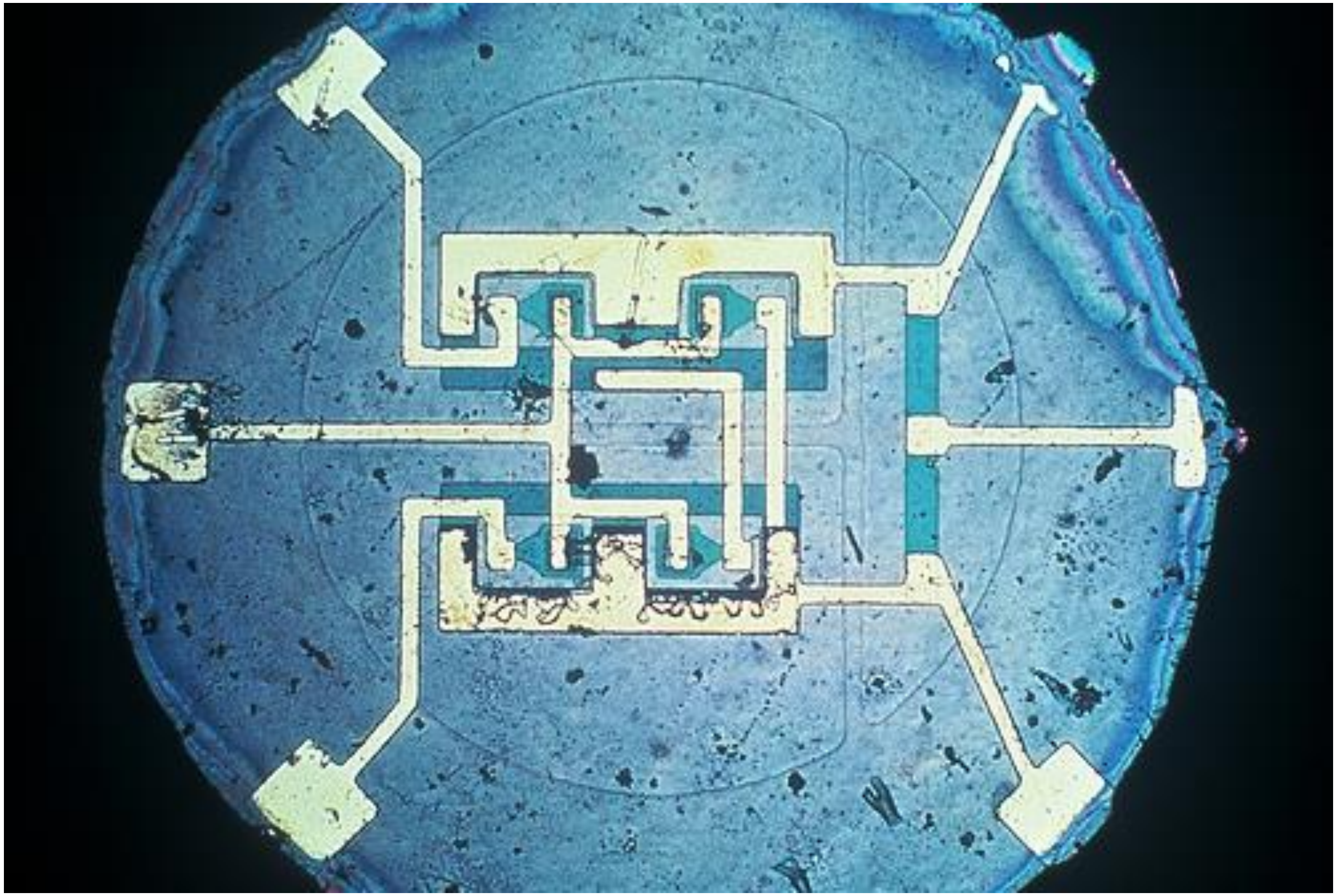
During the cold war the launch of Sputnik-1 by the Soviet Union in 1957 both traumatized and galvanized the United States. It shocked the U.S. into believing it was behind the Soviet Union in innovation. In response, one of the many U.S. national initiatives (DARPA, NASA, Space Race, etc.) to spur innovation was a new government agency to fund new companies. The Small Business Investment Company (SBIC) Act in 1958 guaranteed that for every dollar a bank or financial institution invested in a new company, the U.S. government would invest three (up to $300,000.) So for every dollar that a fund invested, it would have four dollars to invest.

In 1956, William Shockley founds the Shockley Semiconductor Laboratory to produce semiconductor-based transistors to replace vacuum tubes. In October 1957, 8 ‘traitors’ formed Fairchild, the first venture-funded startup of the Silicon Valley.



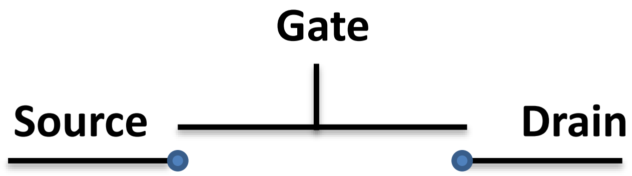
At least 60 semiconductor companies have been founded in Silicon Valley between 1961 and 1972, mostly by former Fairchild engineers and managers.

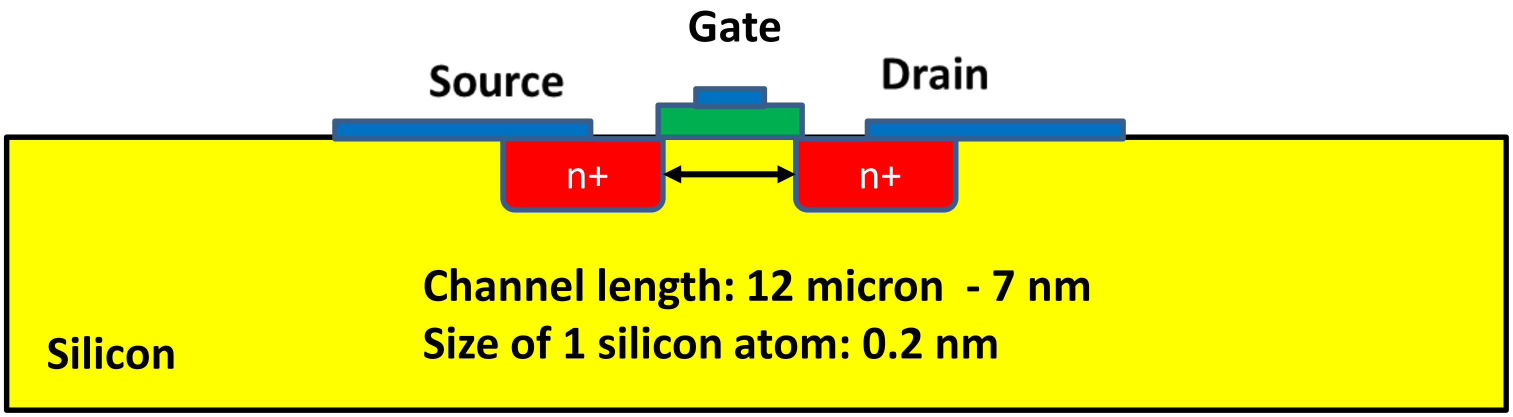
Andrew Grove, founder of Intel in 1968

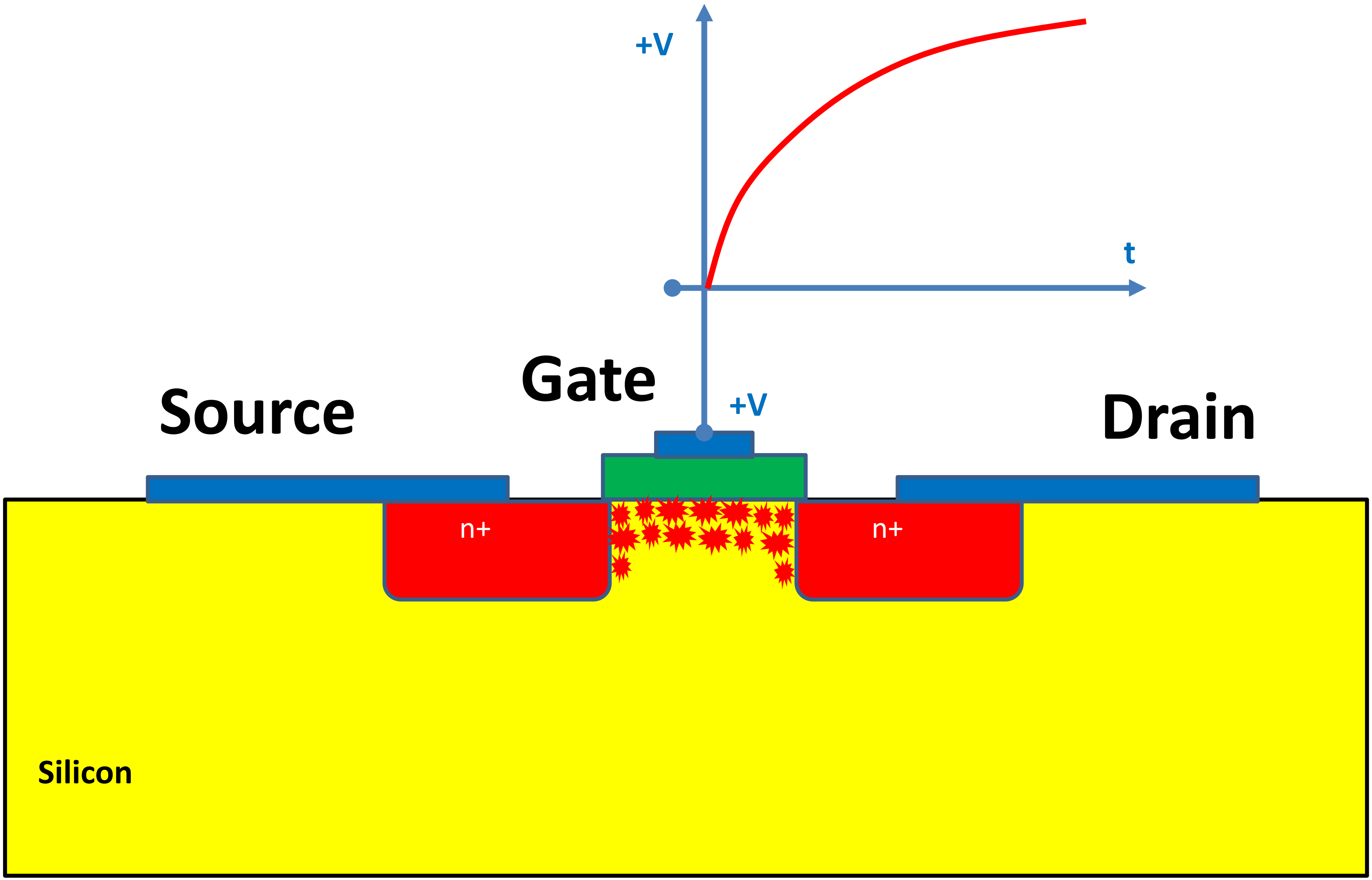


The first germanium chip consisting of 4 transistors + 3 resistors + 1 capacitor Jack Kilby of Texas Instruments, 1958

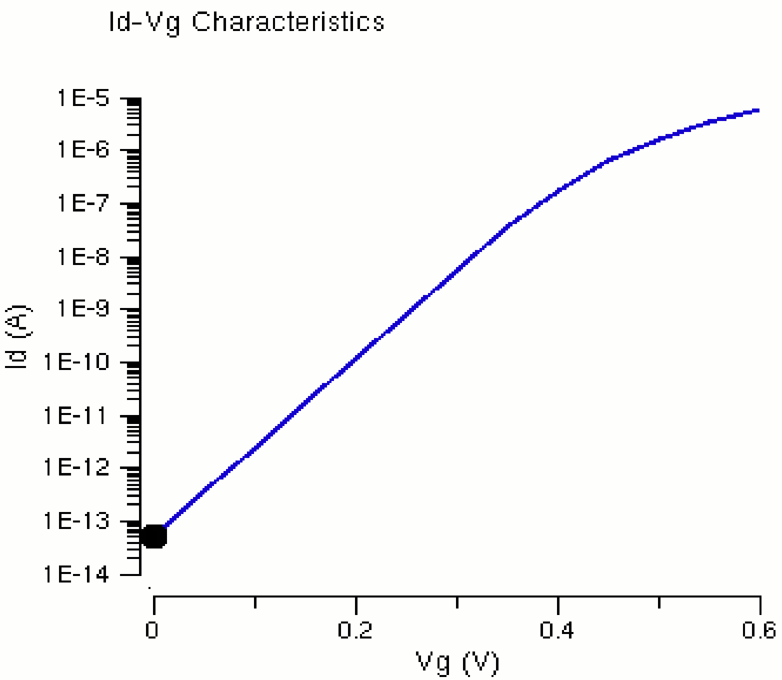
N-MOS transistor

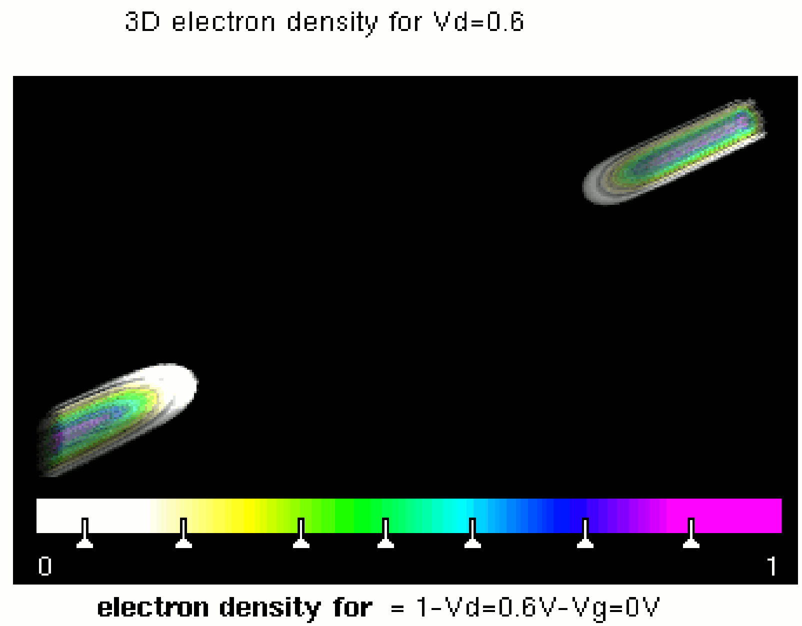


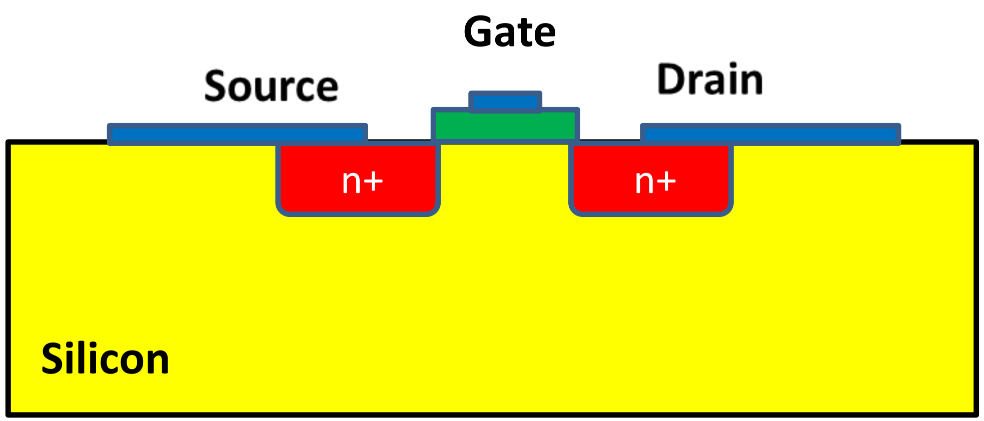




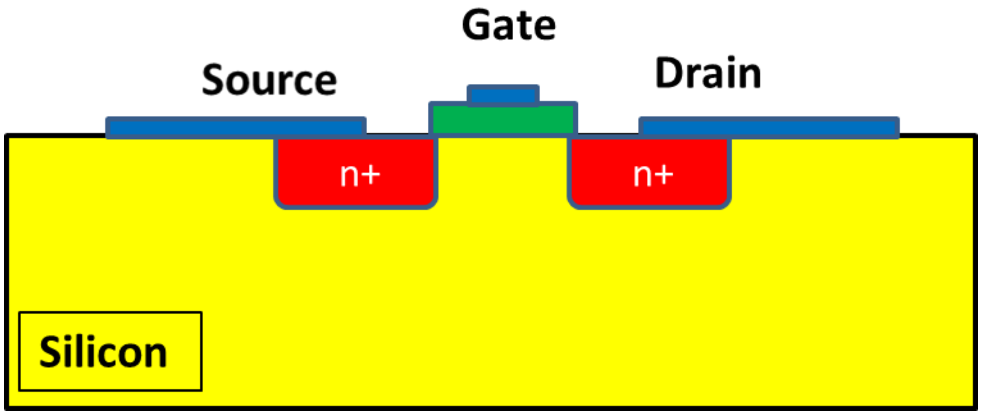
+V
t
Gate
+V
Source
Drain
n+
n+
Silicon

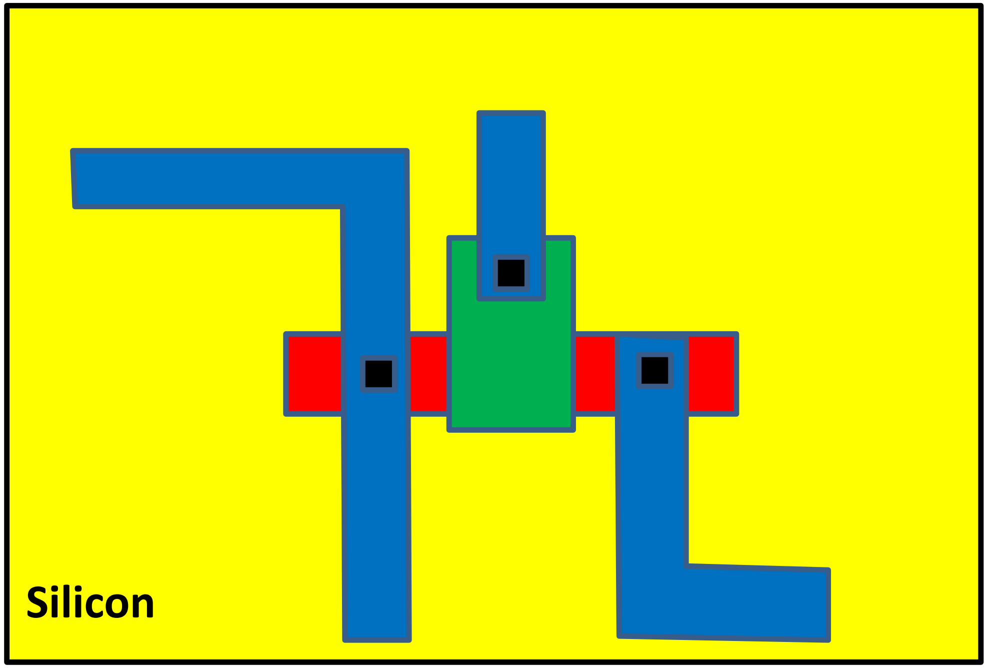


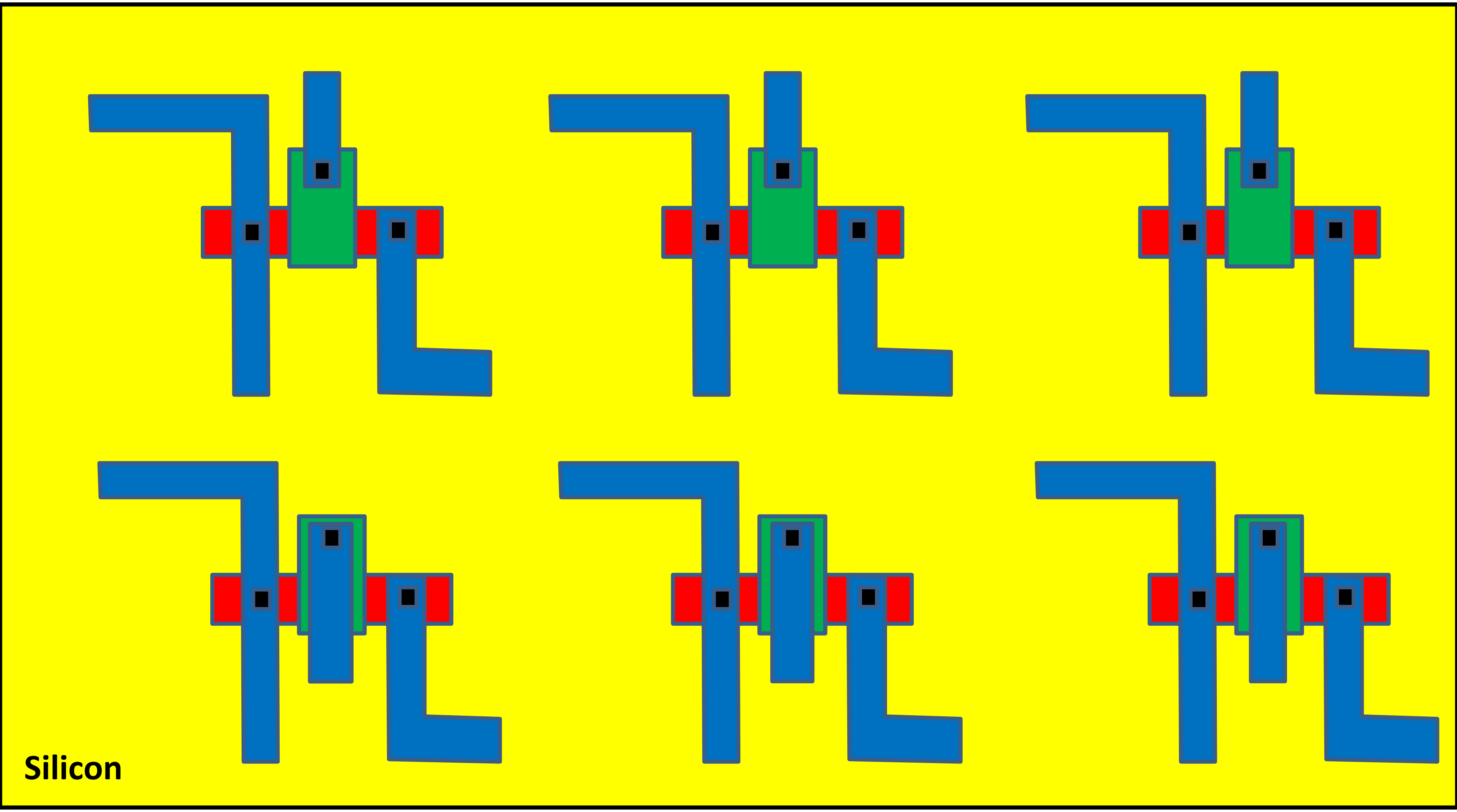


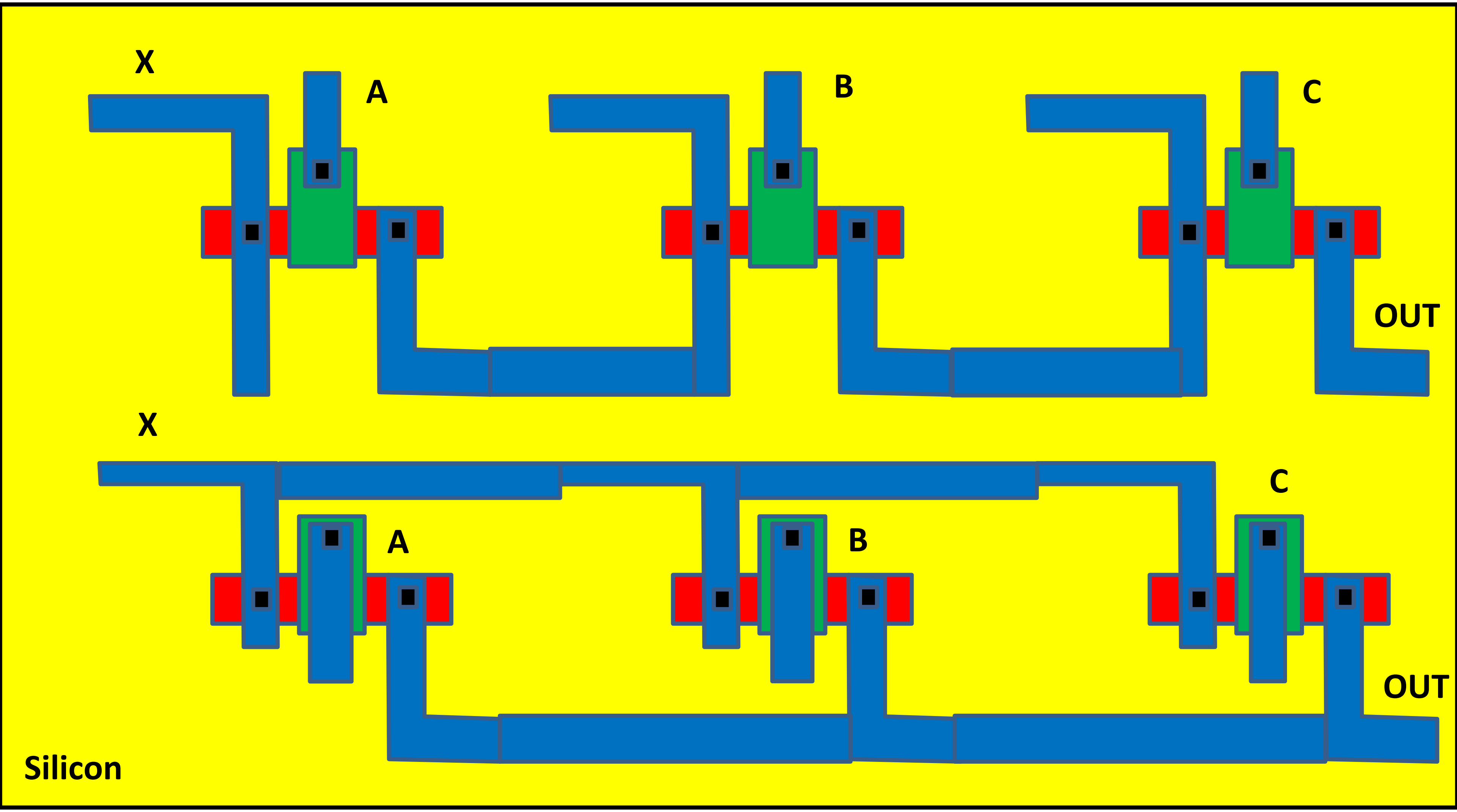


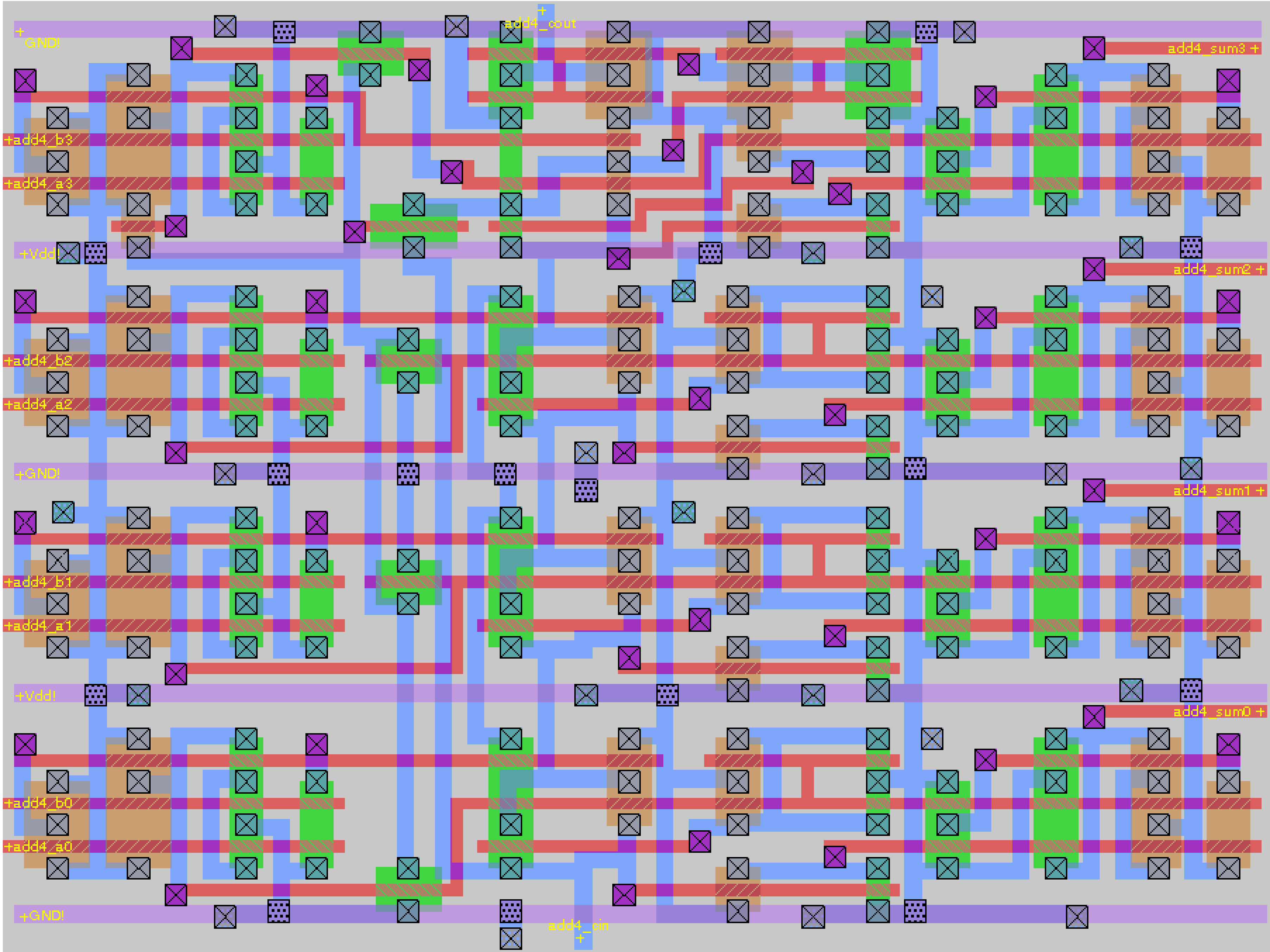
Researchers from IBM and Georgia Tech created a new speed record when they ran a supercooled silicon-germanium transistor above 500 GHz at a temperature of 4.5 K.


Gate
Source
Drain
n+
n+
Silicon

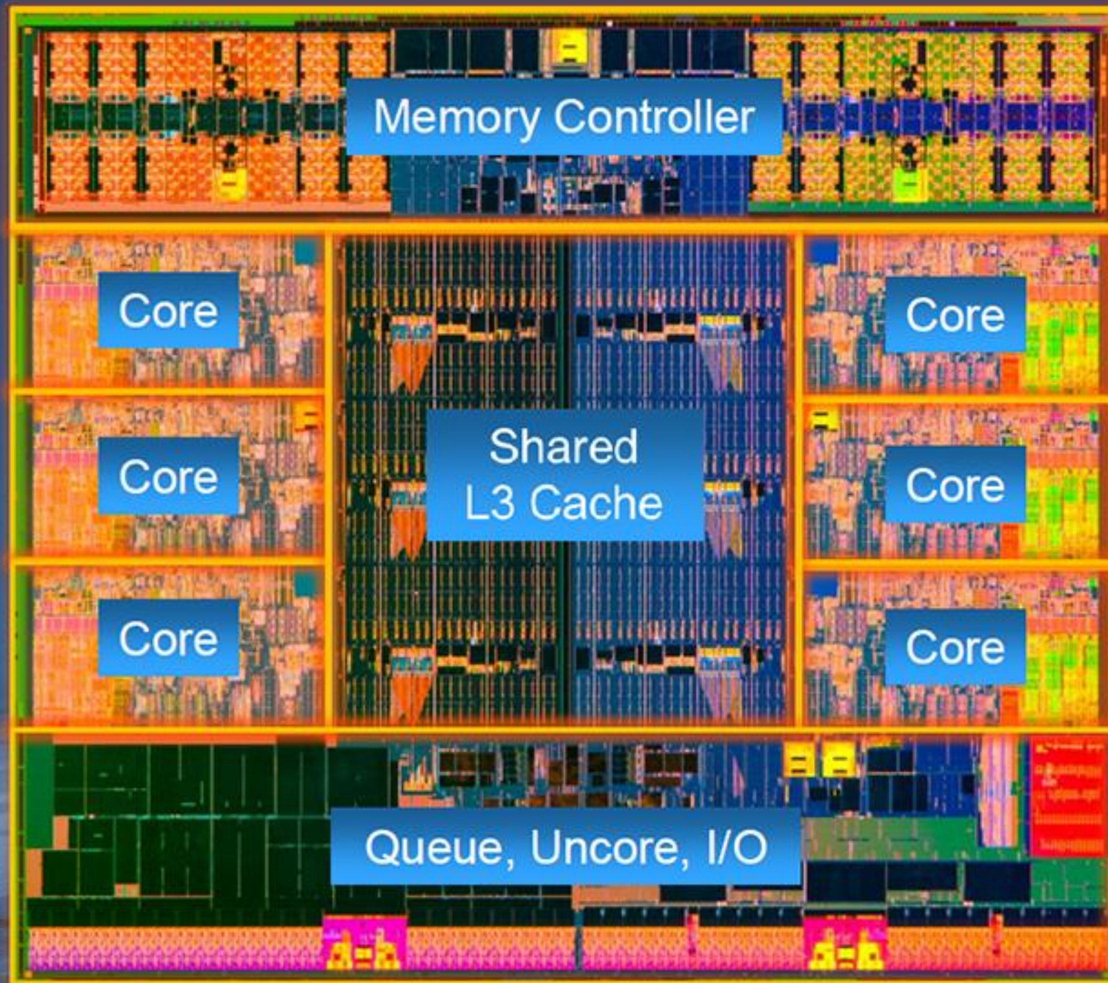

Silicon


Silicon


X
A
B
C
OUT
X
A
B
C
OUT
Silicon


GND!
add4_cout
add4_sum3
add4_b3
add4_a3
Vdd!
add4_sum2
add4_b2
add4_a2
GND!
add4_sum1
add4_b1
add4_a1
Vdd!
add4_sum0
add4_b0
add4_a0
GND!
add4_cin

Intel® Core™ i7-4960X Processor Die Detail



Total number of transistors 1.86B

Die size dimensions 15.0 mm x 17.1 mm [257 mm^2]

** 15MB of cache is shared across all 6 cores

*Other names and brands may be claimed as the property of others.

 Under embargo until 12:01am PT September 3rd, 2013

KLA Tencor cleanroom, 1990

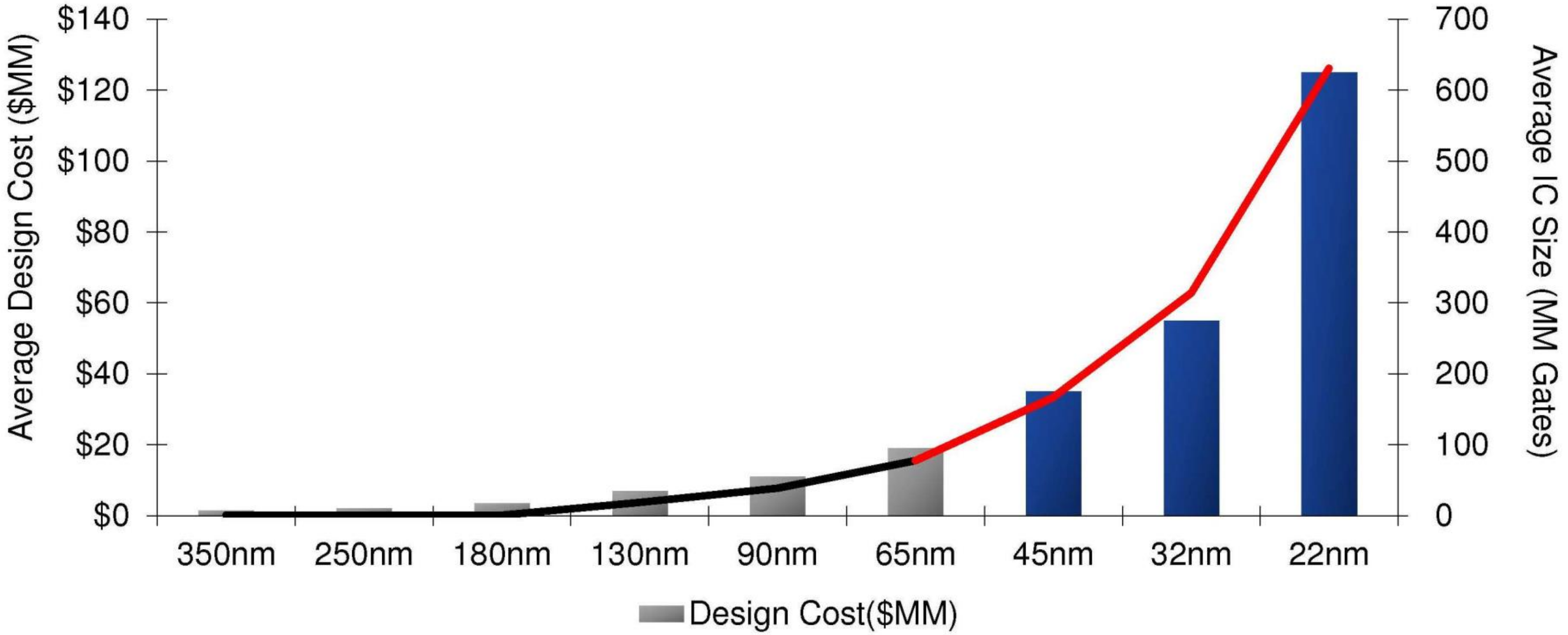
Micro-clean cleanroom, 2000

Ultra-clean pipeline, 2014

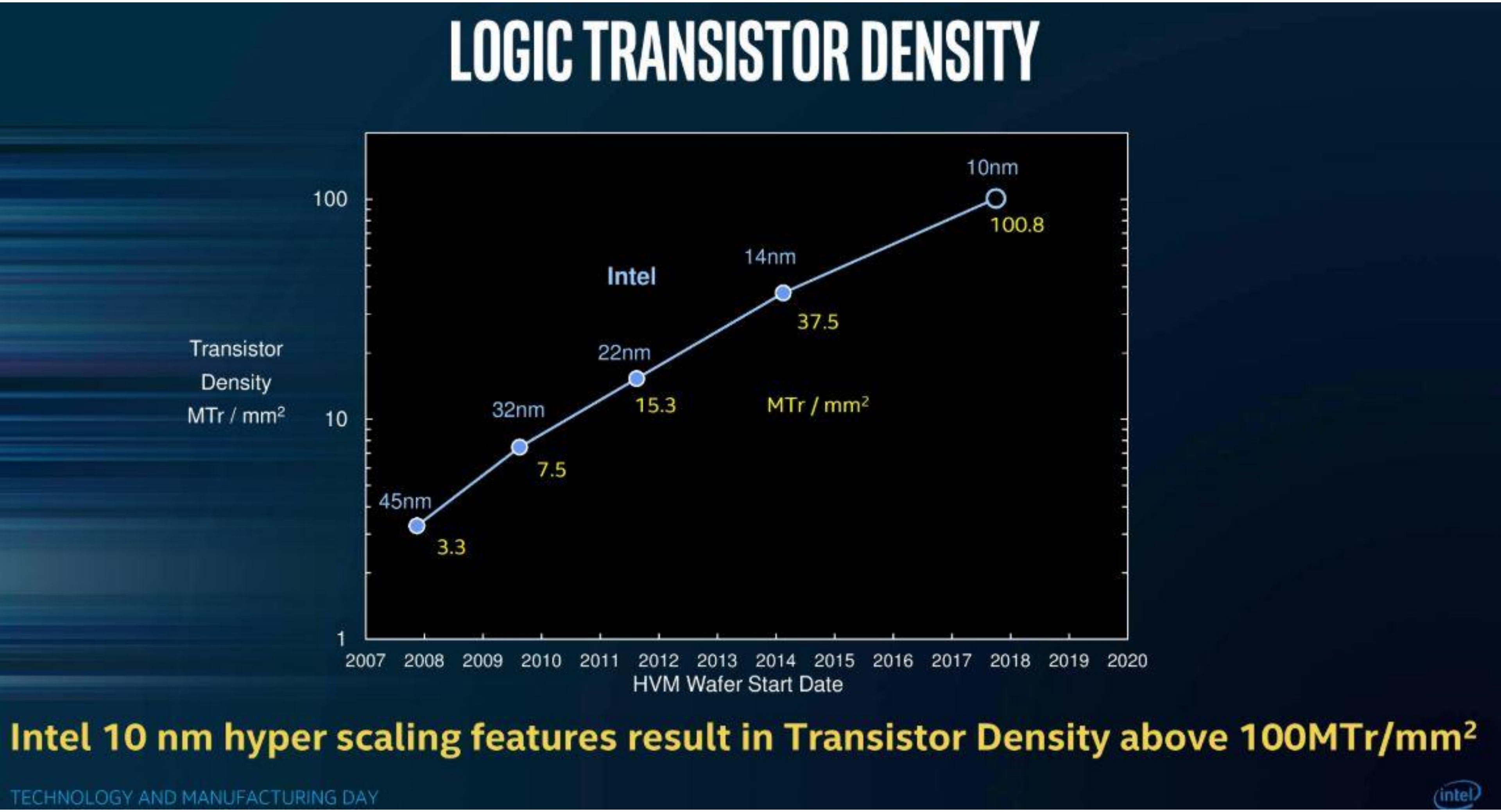
Sub-20 nm FinFET product line


A fully assembled EUV system weighs approximately 100.000 kilograms

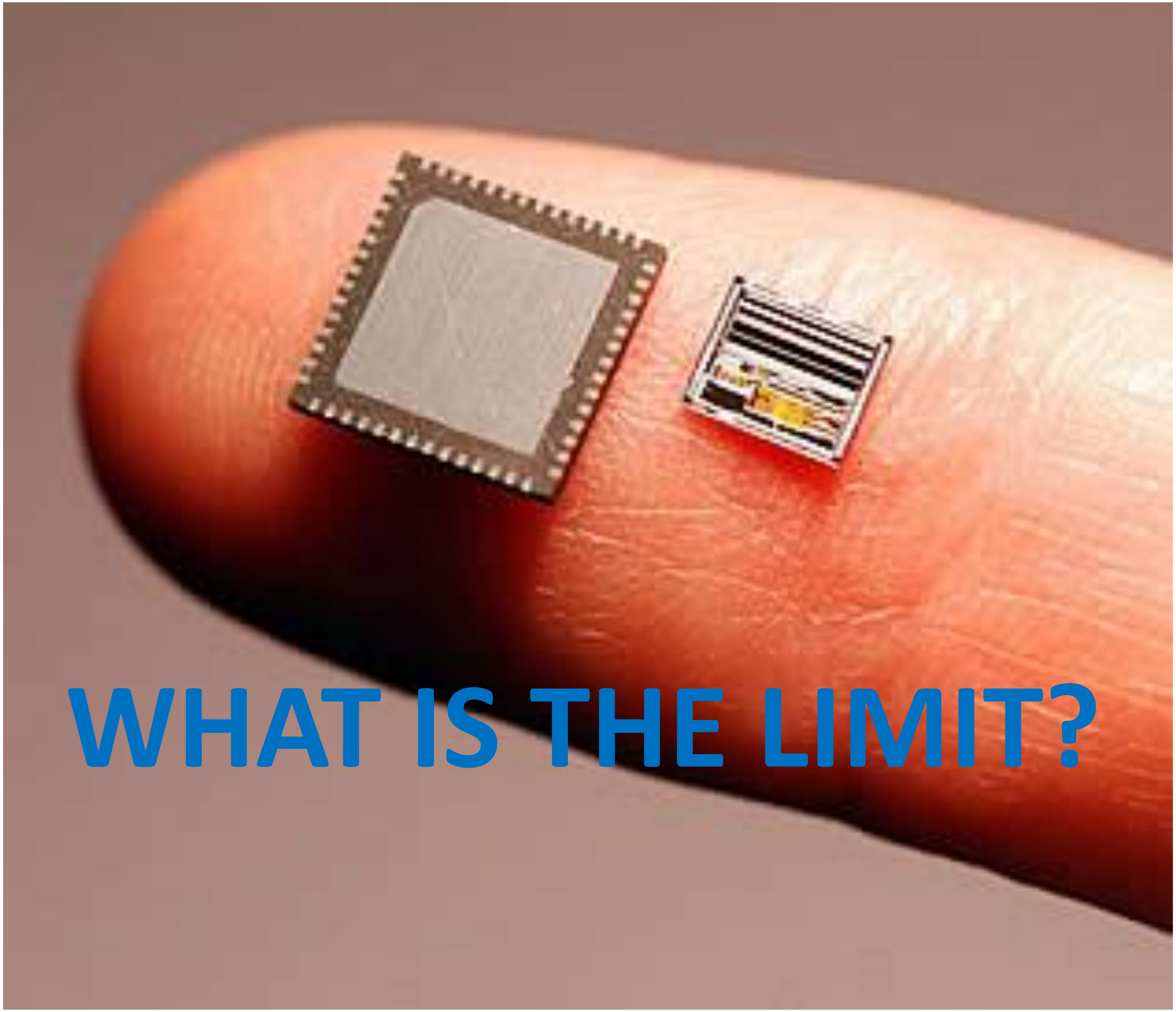
Cost of being a semiconductor supplier escalating

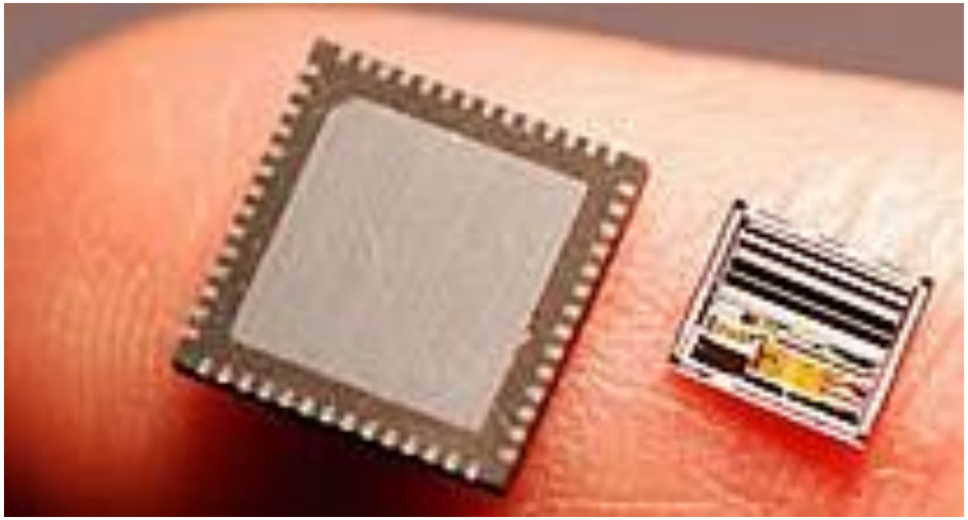


- The cost of designing at 45nm and below is escalating
- Design starts at 45nm and below are growing at 75% CAGR



Intel's Process Node Density									
	90 nm	65 nm	45 nm	32 nm	22 nm	14 nm	14 ++	10 nm	7 nm*
Year	2004	2006	2008	2010	2012	2014	2018	2019	*2023*
Density MTr/mm2	1.45	2.08	3.33	7.11	16.5	44.67	37.22	100.76	*237.18*


WHAT IS THE LIMIT?



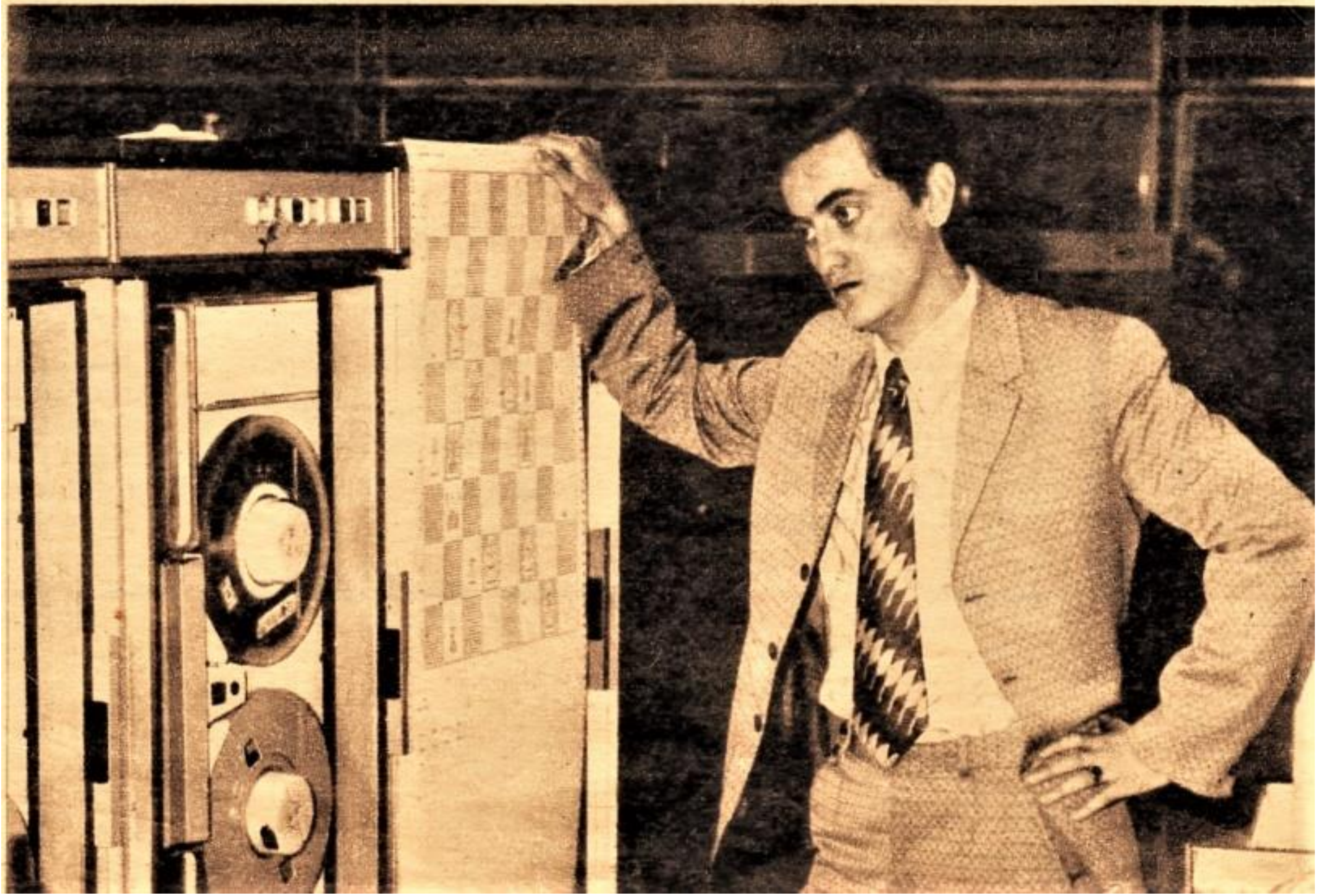
Quantum effects cannot be ignored anymore!

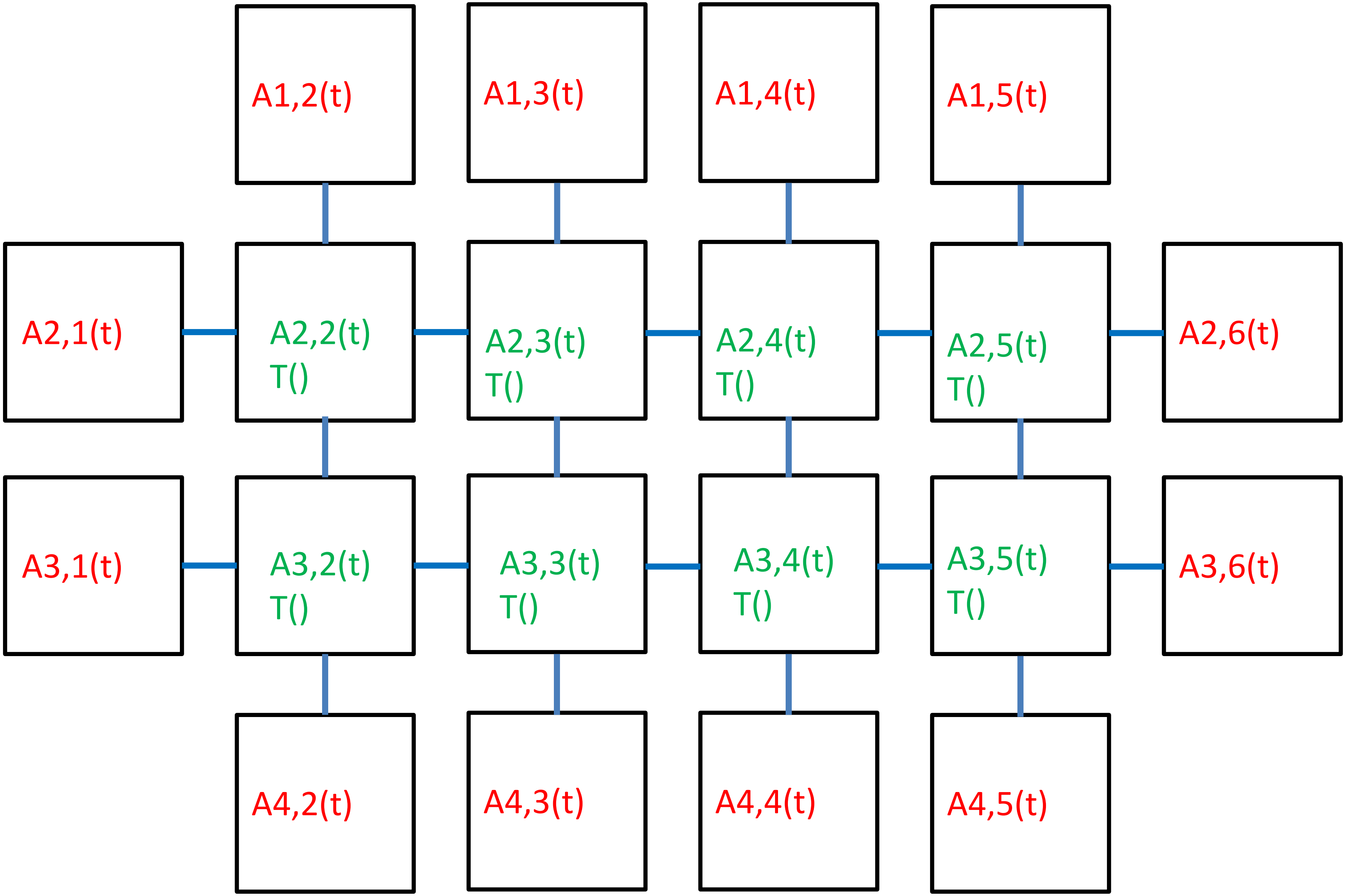
Escalating manufacturing costs!!!!!
Only 3 semiconductor foundries are currently working on a 7nm process: Intel, Samsung, TSMC.

What is next?

Könyves Kálmán krt. 48-52
1971, szeptember 2 – 1979 november 8

A kutató és eszköze. Kálmán Sándor az elektronikus számítógép előtt

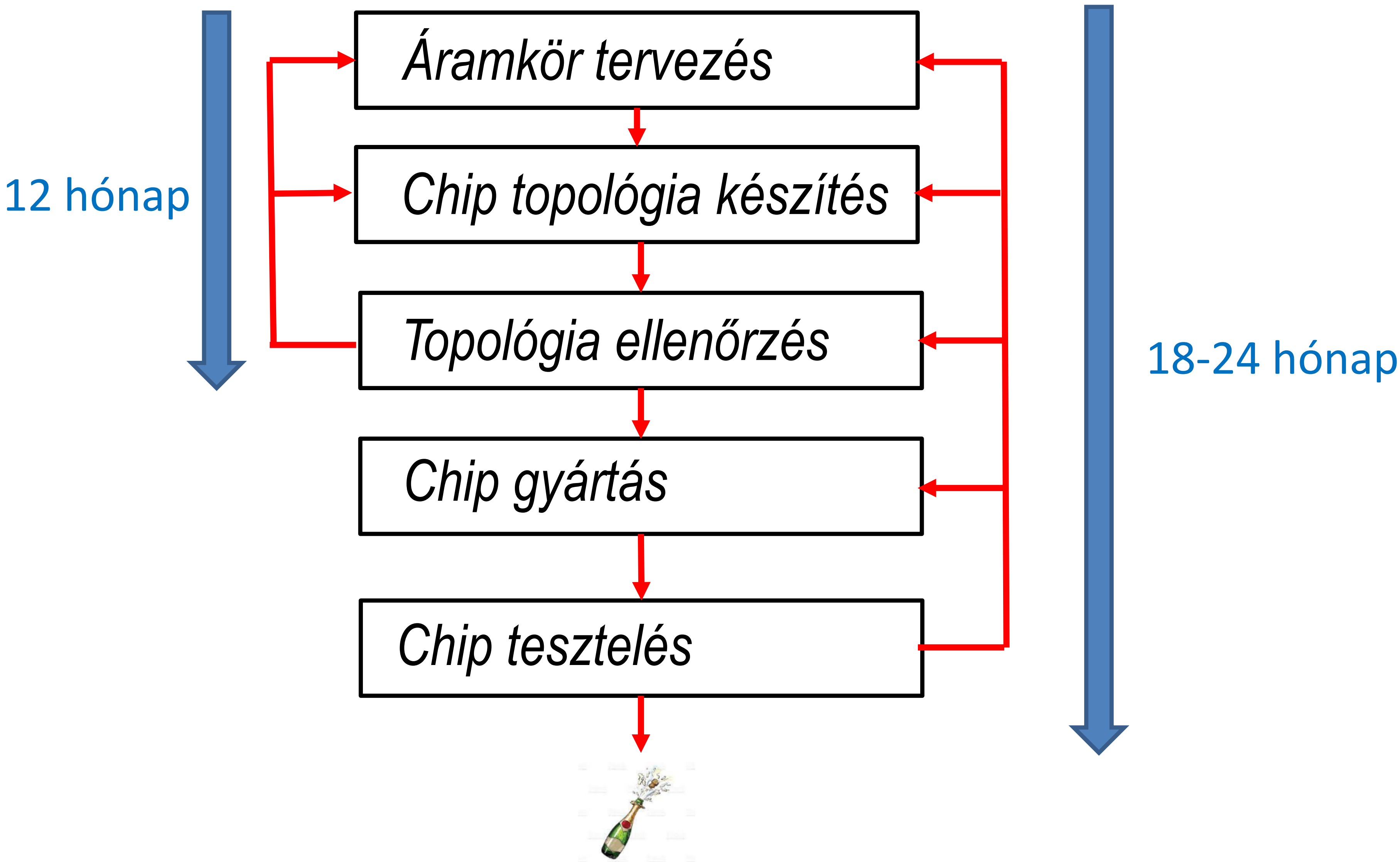


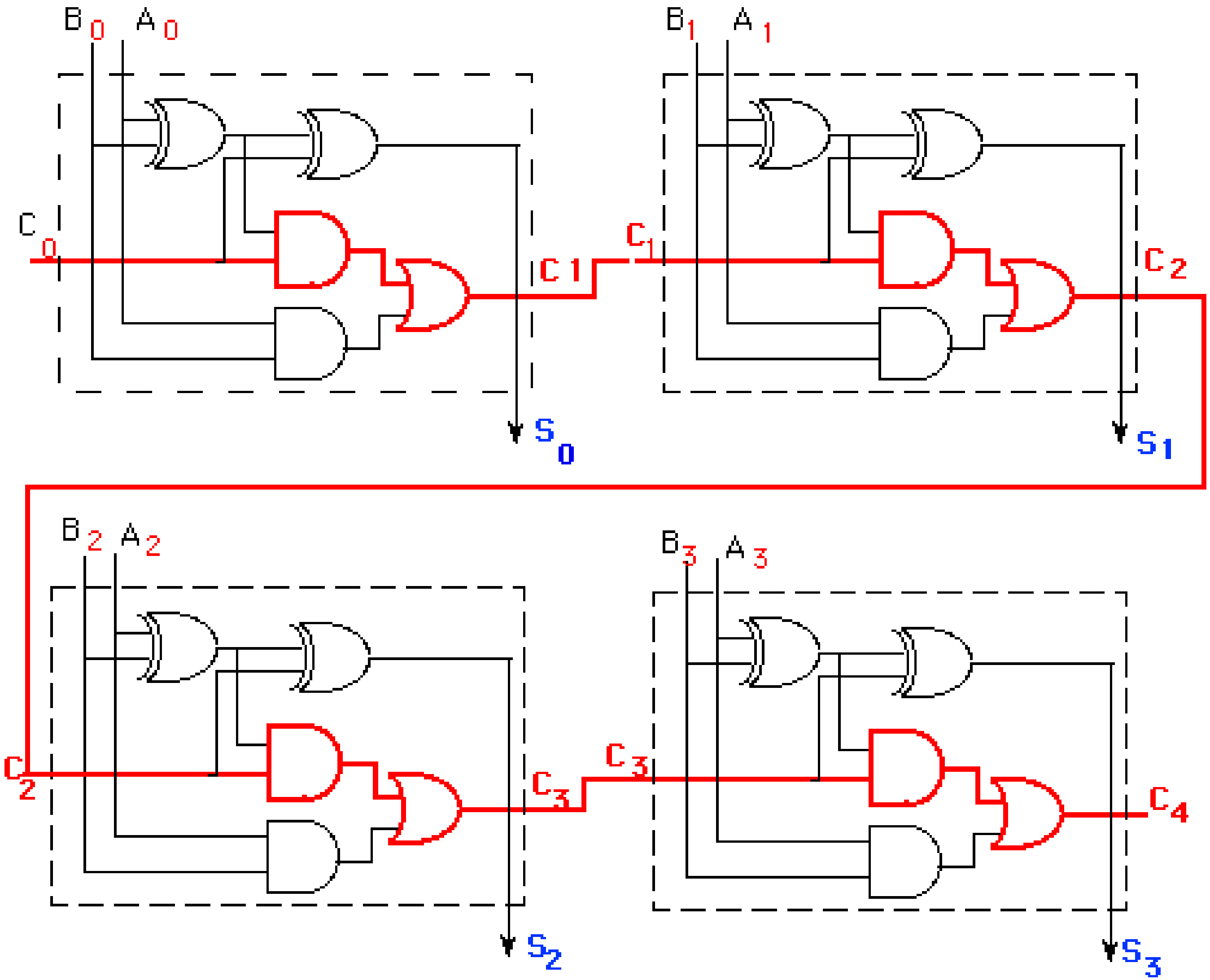


CODD: A2,3(t)= T[A2,3(t-1), A2,2(t-1), A1,3(t-1), A2,4(t-1), A3,3(t-1)]

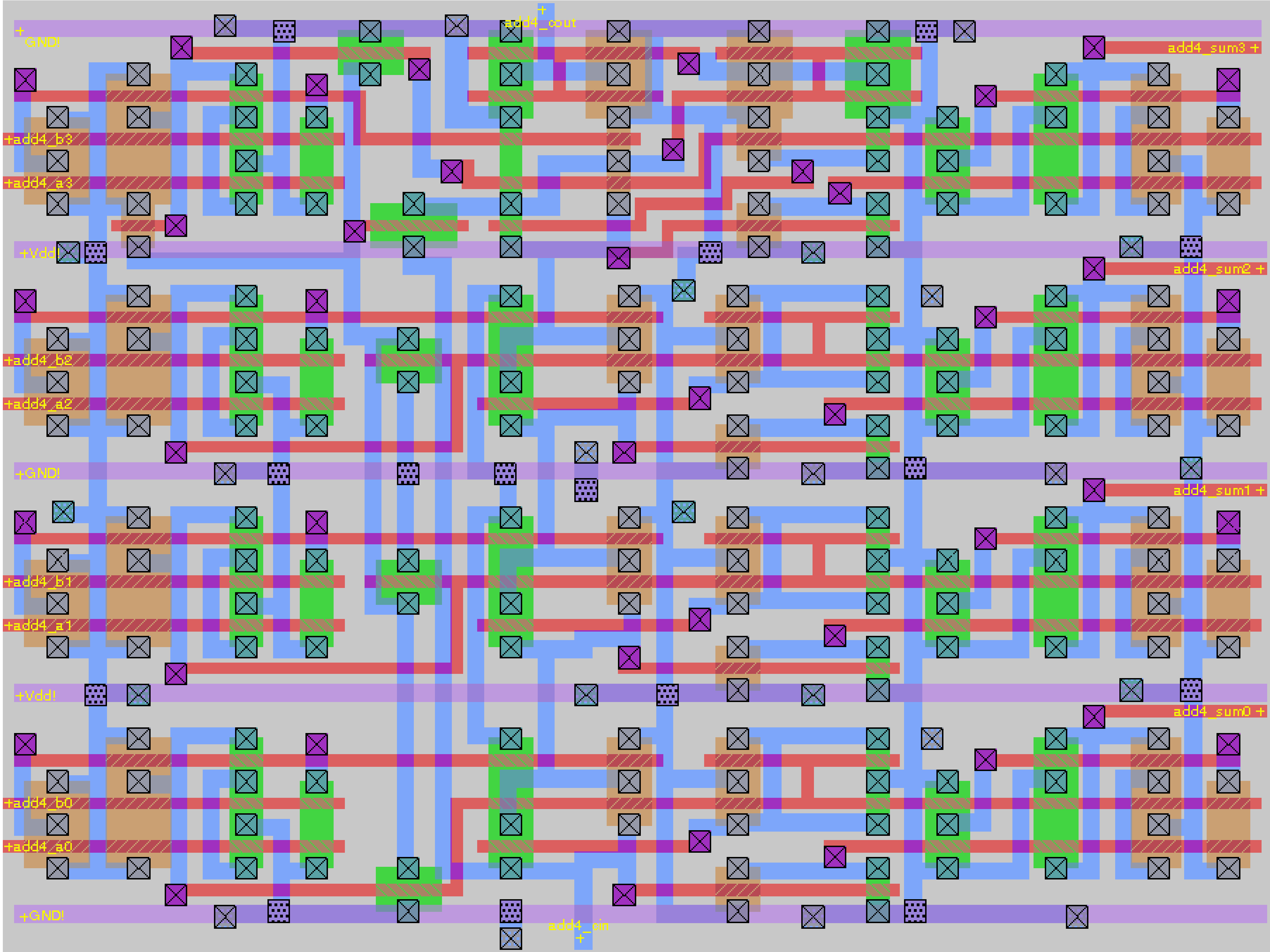
Szilícium Völgy
1980-2019

Ötlettől a chip megvalósításig

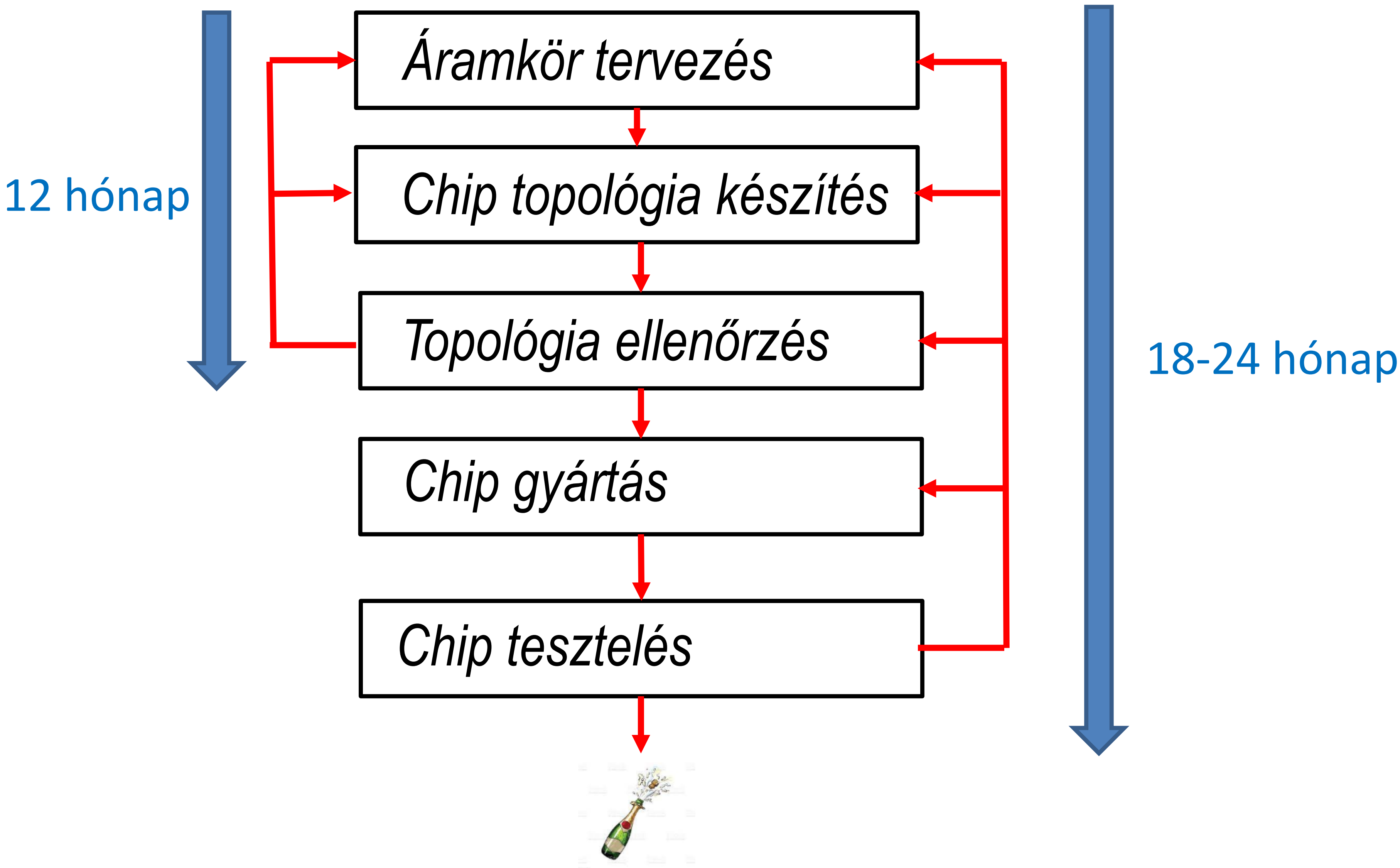


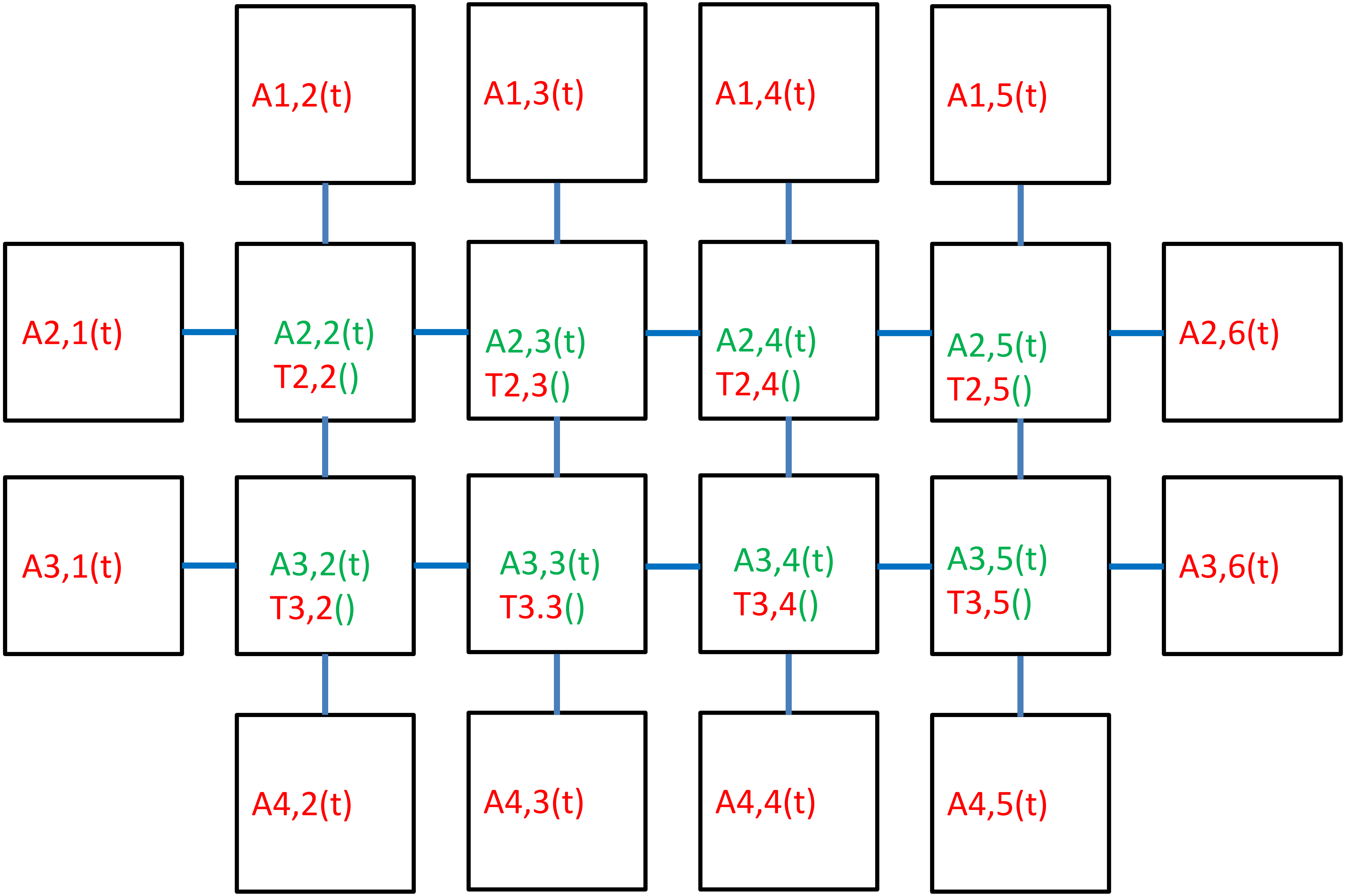


B0 A0
C0
C1
C1
S0
B1 A1
C2
S1
B2 A2
C2
C3
C3
S2
B3 A3
C4
S3


GND!
add4_cout
add4_sum3
add4_b3
add4_a3
Vdd!
add4_sum2
add4_b2
add4_a2
GND!
add4_sum1
add4_b1
add4_a1
Vdd!
add4_sum0
add4_b0
add4_a0
GND!
add4_cin

Ötlettől a chip megvalósításig





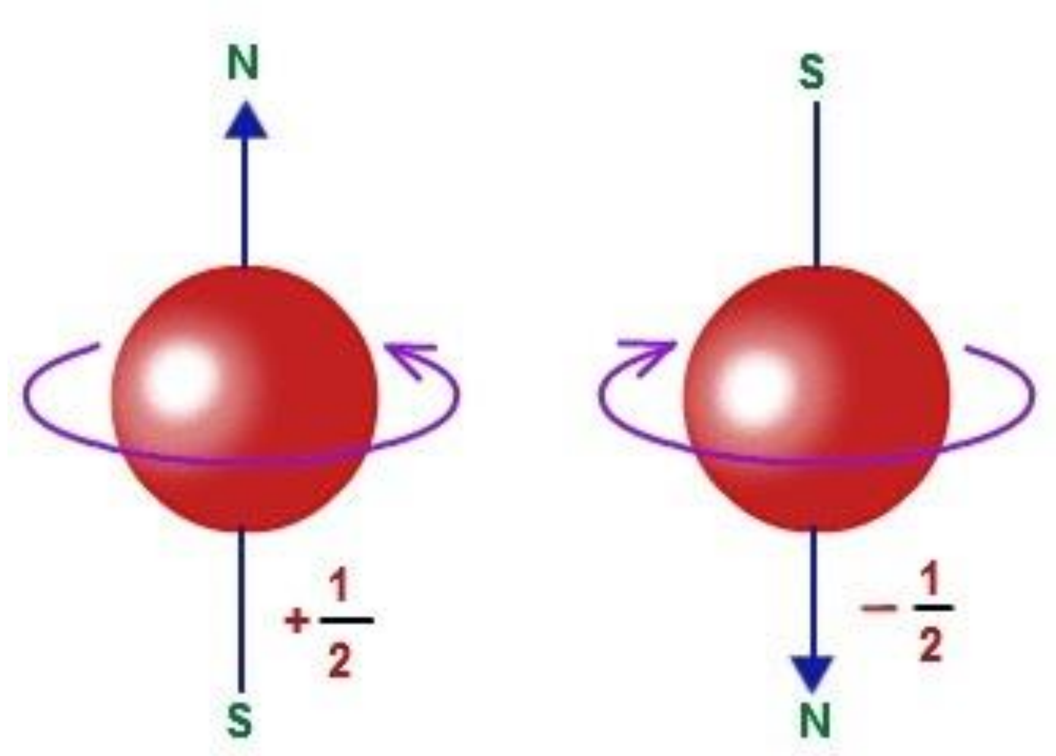
FPGA: A2,3(t)= T2,3[A2,3(t-1), A2,2(t-1), A1,3(t-1), A2,4(t-1), A3,3(t-1)]


Sandor Kalman
2000

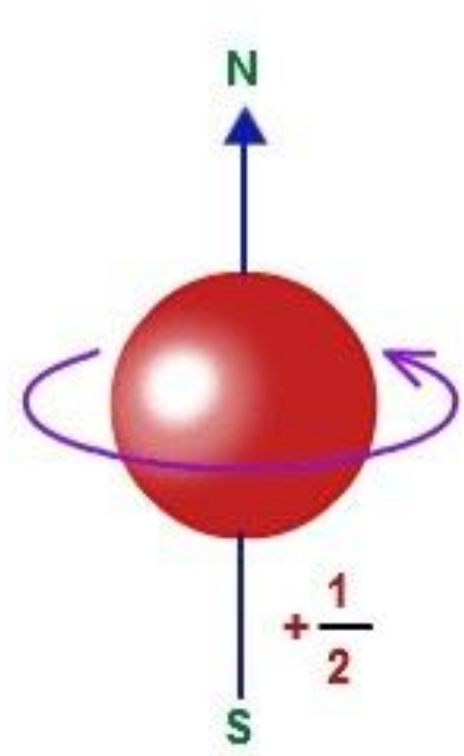
A kvantumszámítógépekek alapjai

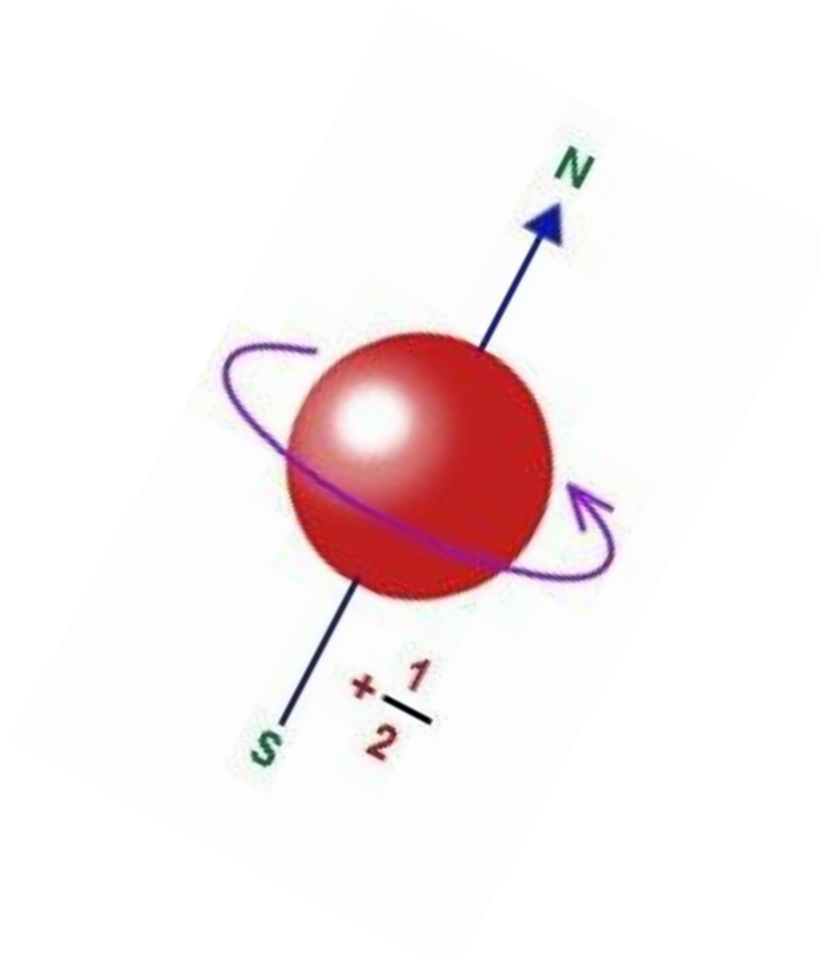
1. *Ez bizony nem az amire gondolunk. Miért kell ez nekünk?*
2. *A kvantumszámítógépek matematikai modellje.*
3. *A klasszikus és a kvantum alapú felhasználói modellek összehasonlítása.*
4. *Miben rejlik a kvantumszámítógépek gyorsasága?*
5. *Mi várható 10 év múlva?*

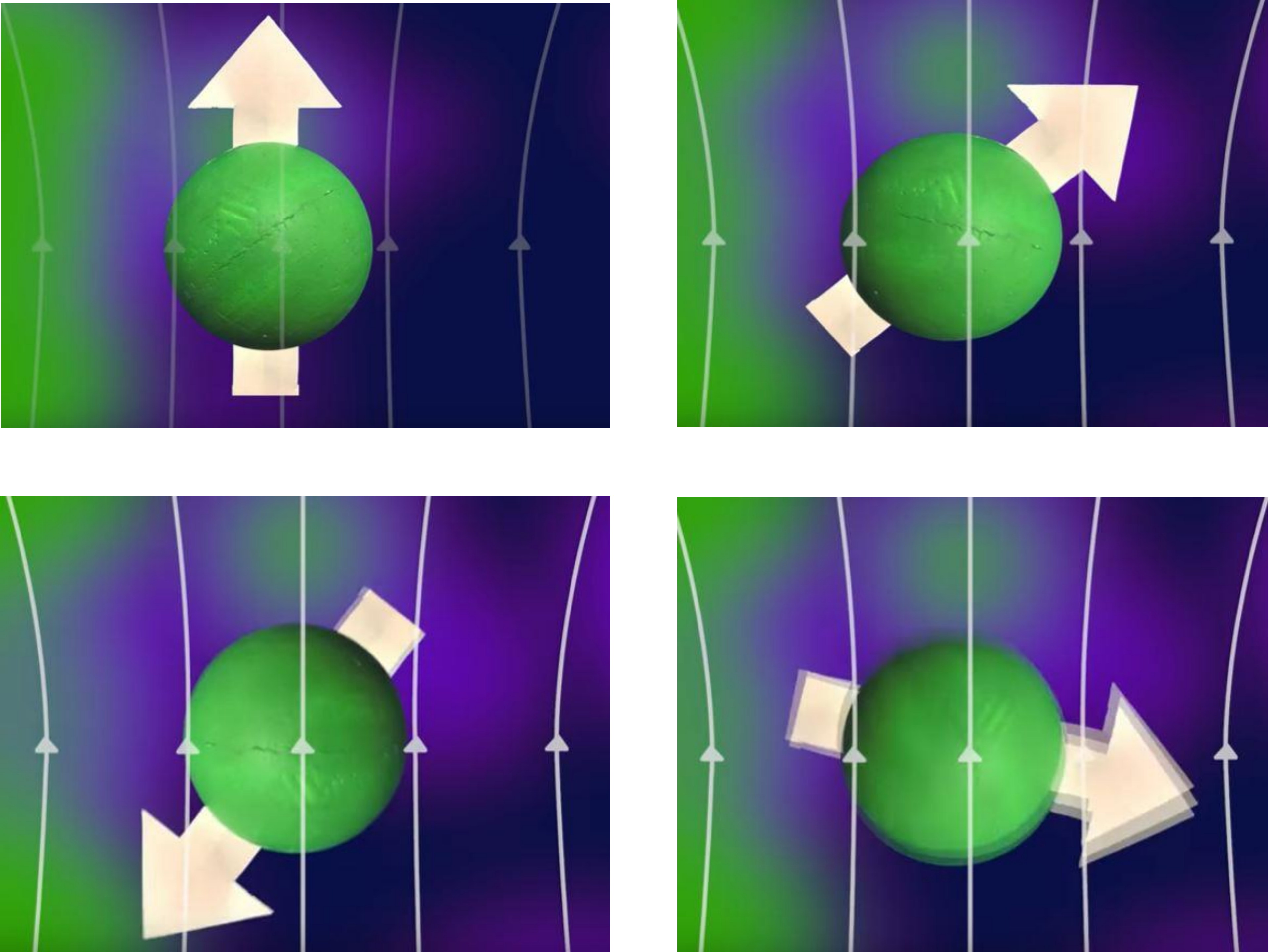
Atoms, electrons spin up or down in a magnetic field. The direction of the magnetic field determines the direction of the spin (clockwise or counterclockwise).



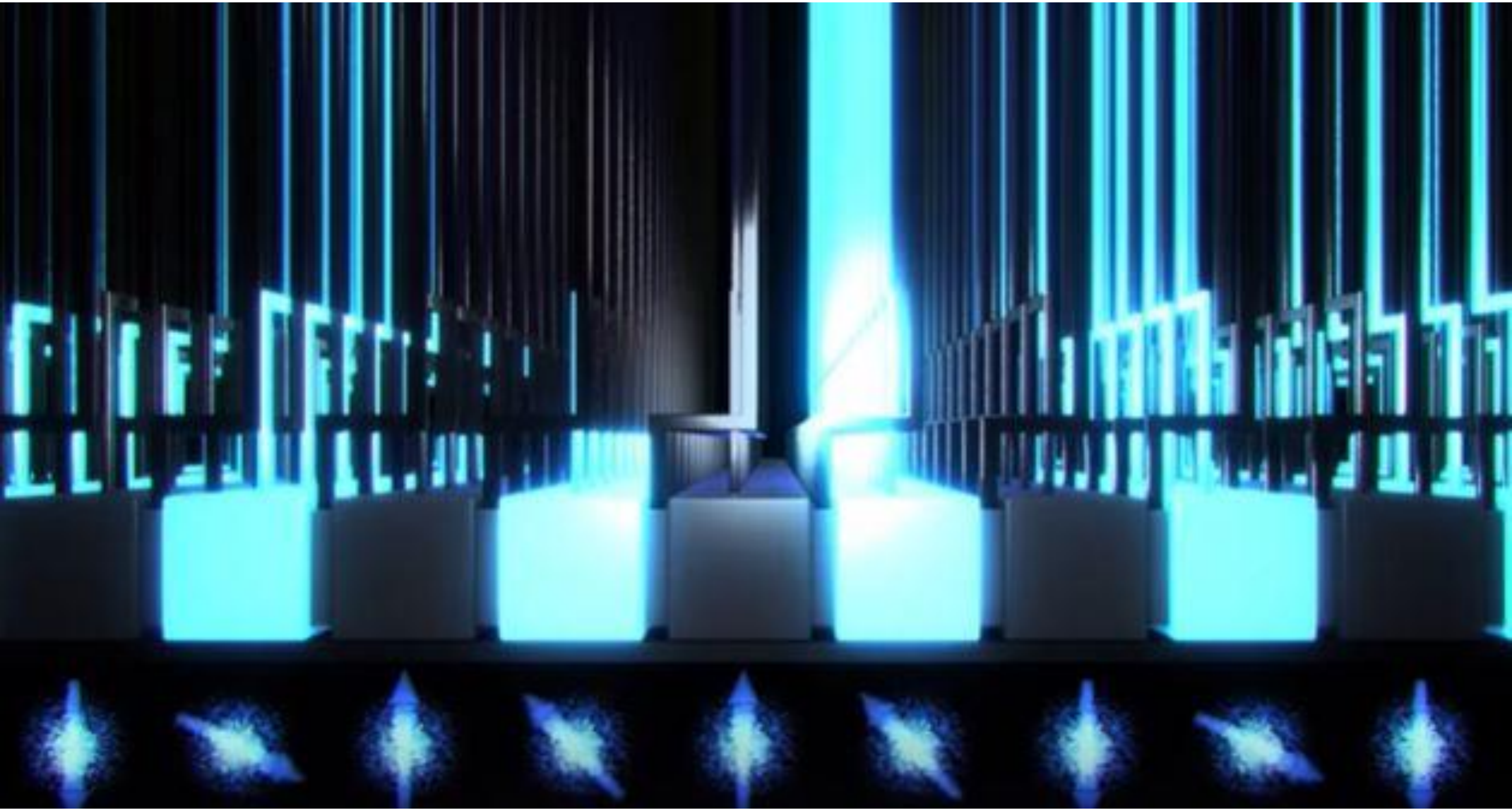
Now imagine spinning at a tilt. That ability is the heart of superposition.



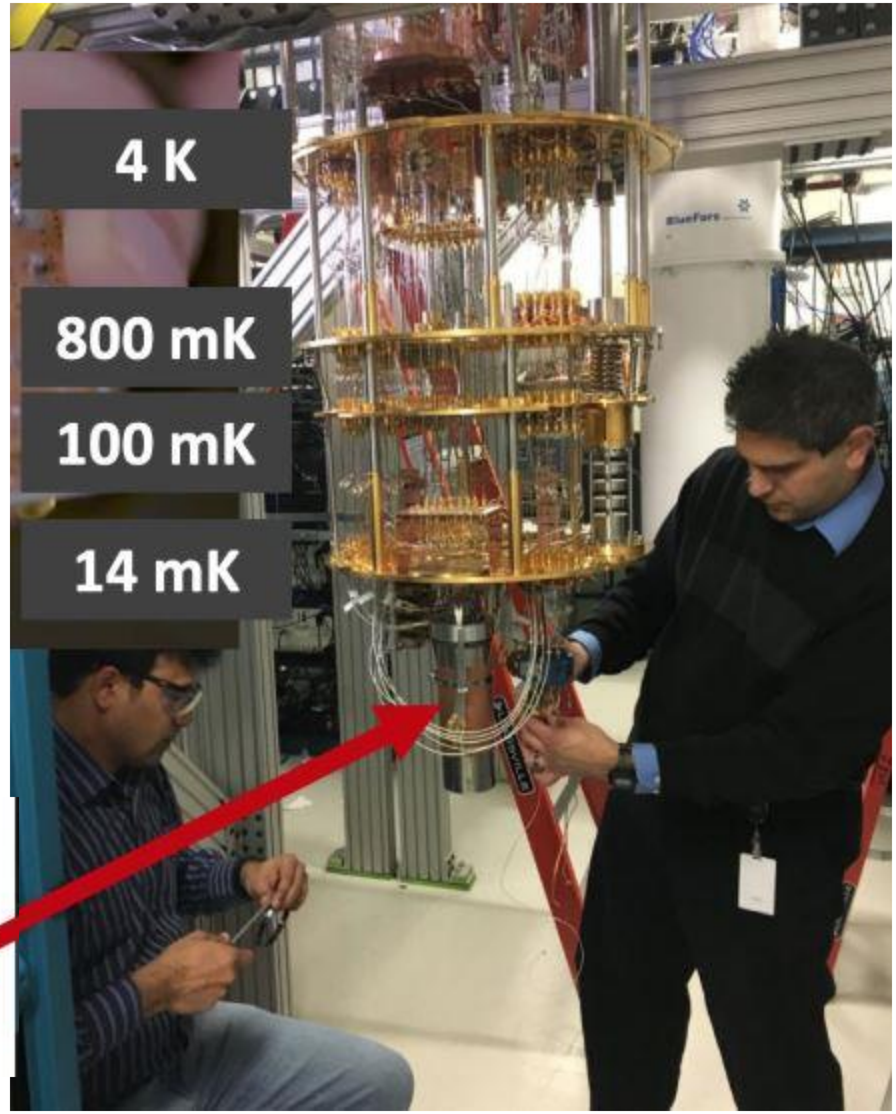




Quantum computers controll a series of Qubits

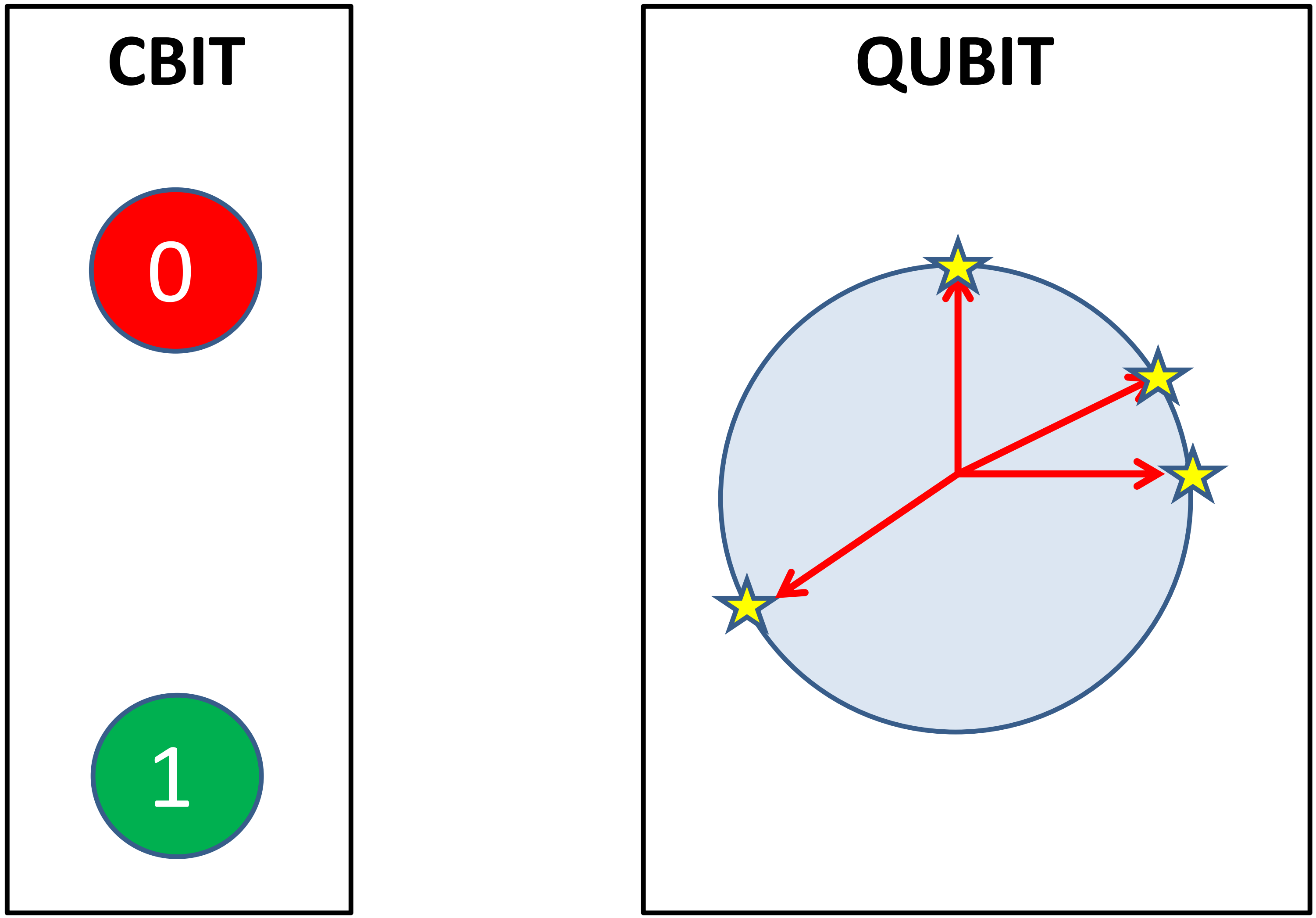


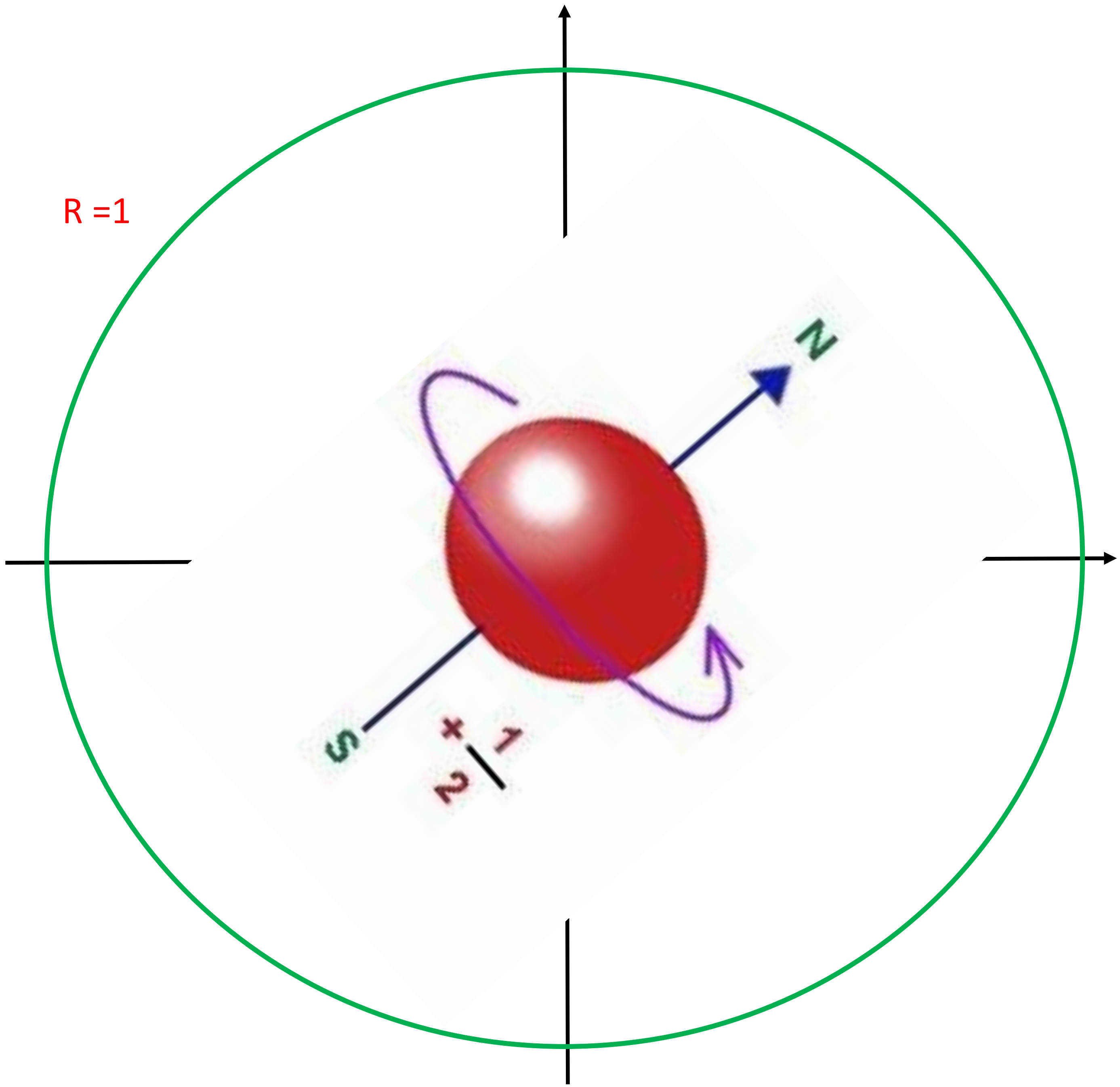

IBM Q

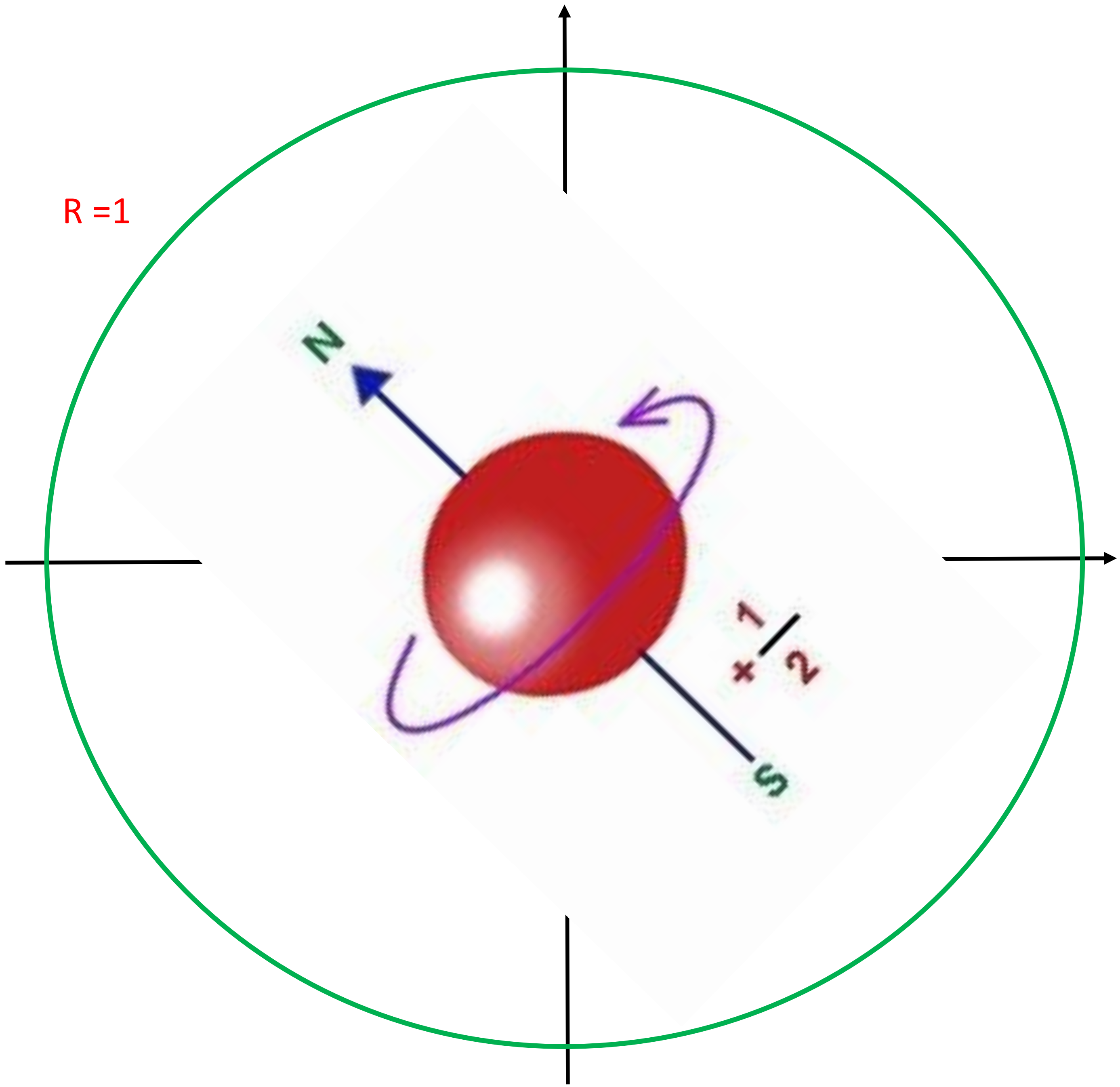


cryostat
temperature
0.014 K

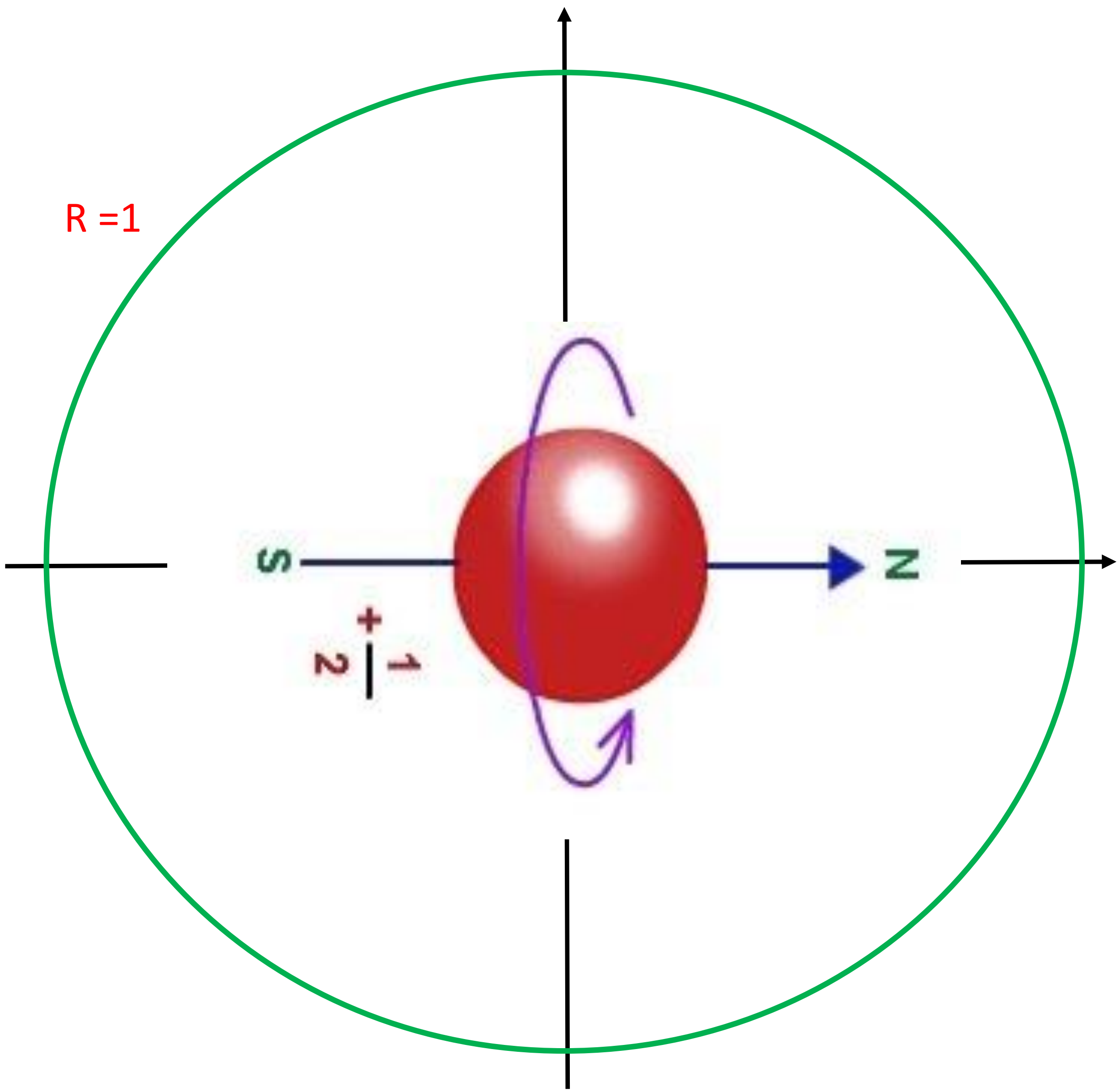
-273.136 Celsius

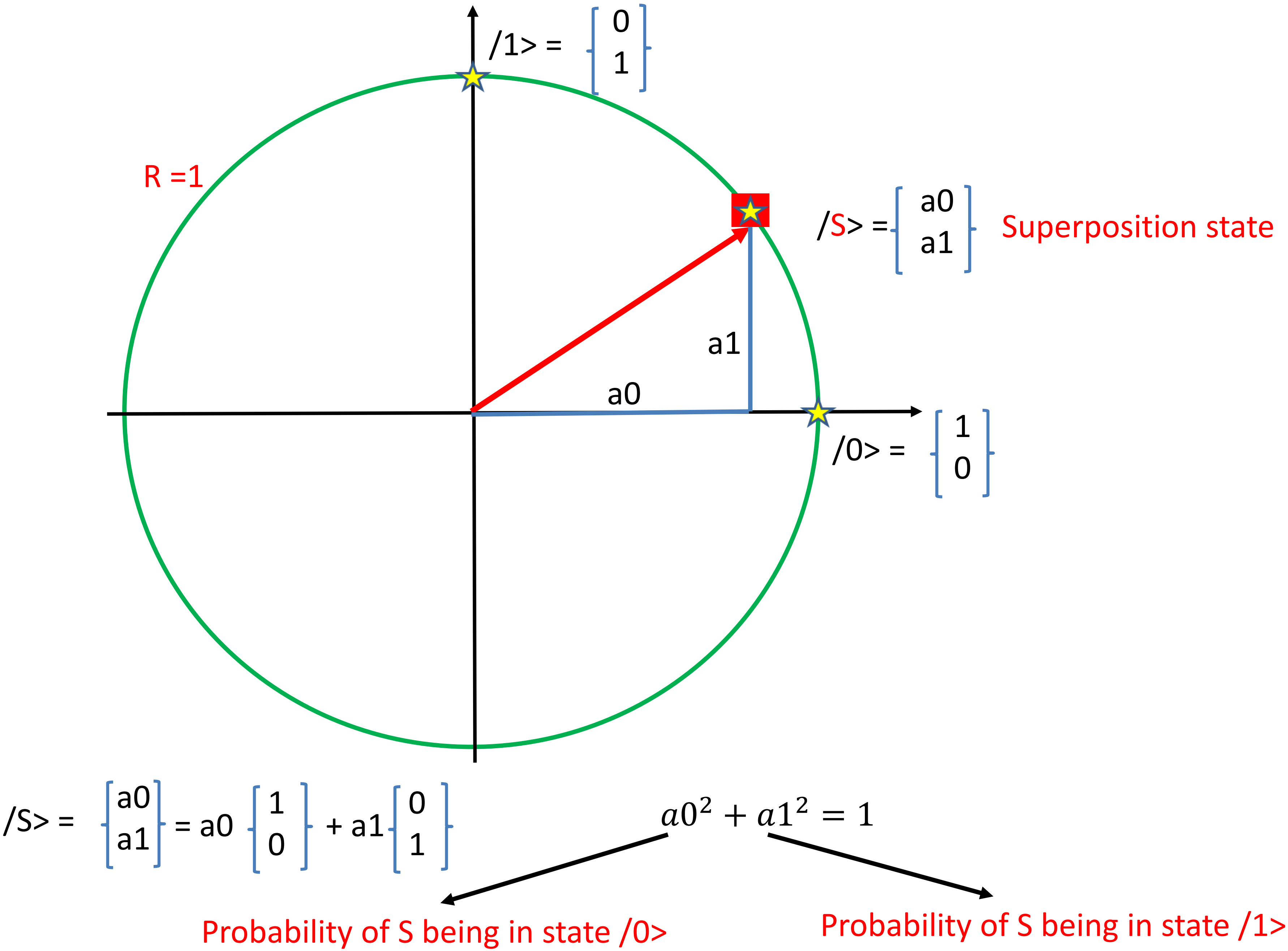

CBIT
0
1
QUBIT


R =1
N
S
+1/2



R =1
N
S
+ 1/2


R =1
S
N
+ 1/2


/1> = [0 1]
R =1
/S> = [a0 a1]
Superposition state
a1
a0
/0> = [1 0]
/S> = [a0 a1] = a0 [1 0] + a1 [0 1]
$a0^2 + a1^2 = 1$
Probability of S being in state /0>
Probability of S being in state /1>

Data representation

	a	/a>
0	0	a0
1	1	a1

	ab	/ab>
0	00	a0*b0
1	01	a0*b1
2	10	a1*b0
3	11	a1*b1

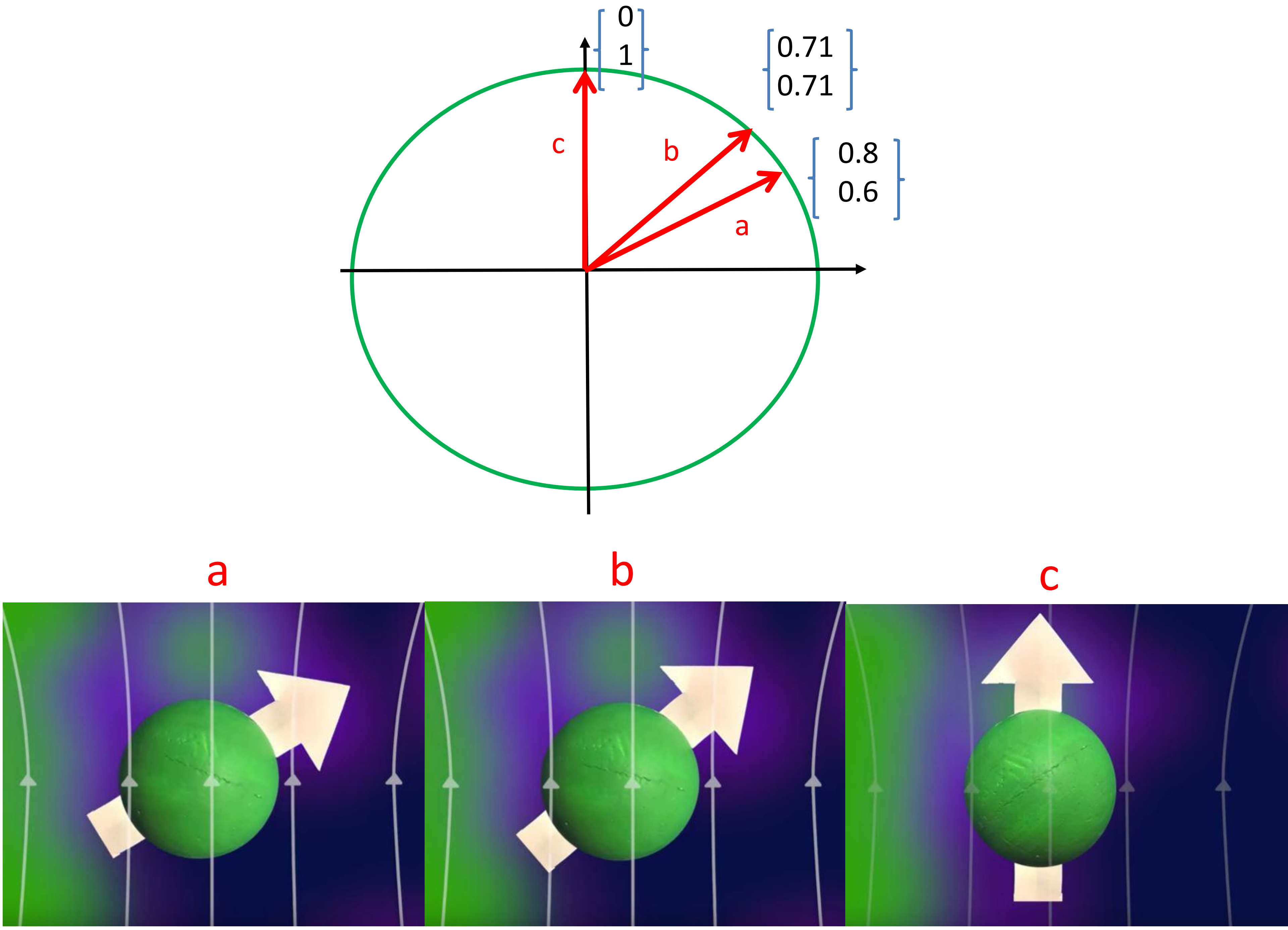
	abc	/abc>
0	000	a0*b0*c0
1	001	a0*b0*c1
2	010	a0*b1*c0
3	011	a0*b1*c1
4	100	a1*b0*c0
5	101	a1*b0*c1
6	110	a1*b1*c0
7	111	a1*b1*c1

/a> = $\begin{bmatrix} a0 \\ a1 \end{bmatrix}$ $\quad a0^2 + a1^2 = 1$

/b> = $\begin{bmatrix} b0 \\ b1 \end{bmatrix}$ $\quad b0^2 + b1^2 = 1$

/c> = $\begin{bmatrix} c0 \\ c1 \end{bmatrix}$ $\quad c0^2 + c1^2 = 1$

$$a0^2 * b0^2 + a0^2 * b1^2 + a1^2 * b0^2 + a1^2 * b1^2 = 1$$



0
1
0.71
0.71
0.8
0.6
c
b
a
a
b
c

a0 = 0.8, a1 = 0.6, b0 = 0.71, b1 = 0.71, c0 = 0, c1=1

/abc> = [a0*b0*c0, a0*b0*c1, a0*b1*c0, a0*b1*c1, a1*b0*c0, a1*b0*c1, a1*b1*c0, a1*b1*c1]

0	0
1	0.57
2	0
3	0.57
4	0
5	0.42
6	0
7	0.42

$$\mathbf{0.57^2 + 0.57^2 + 0.42^2 + 0.42^2 = 1}$$

32.5% 1, 32.5% 3, 17.5% 5, 17.5% 7

	abc
0	000
1	001
2	010
3	011
4	100
5	101
6	110
7	111

	abc
5	101

0	0
1	0
2	0
3	0
4	0
5	1
6	0
7	0

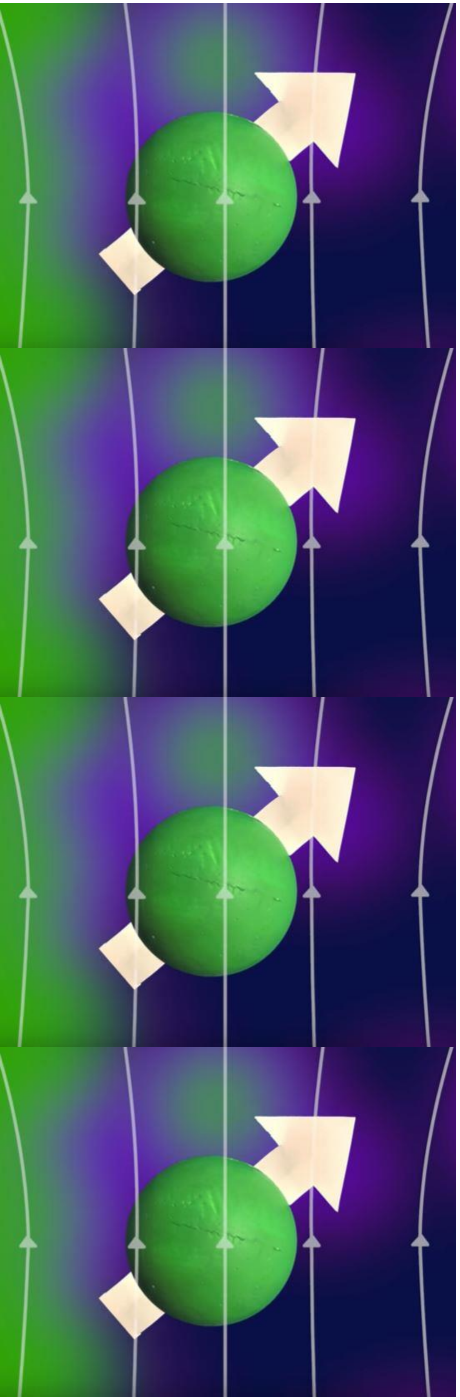
→ **100% 5**

a0 = 0, a1 = 1,
b0 = 1, b1 = 0,
c0 = 0, c1=1

	abcd	
0	0000	→ f(x)
1	0001	→ f(x)
2	0010	→ f(x)
3	0011	→ f(x)
4	0100	
5	0101	
6	0110	
7	0111	
8	1000	
9	1001	
10	1010	→ f(x)
11	1011	
12	1100	
13	1101	
14	1110	
15	1111	→ f(x)

abcd
a0*b0*c0*d0
a0*b0*c0*d1
a0*b0*c1*d0
a0*b0*c1*d1
a0*b1*c0*d0
a0*b1*c0*d1
a0*b1*c1*d0
a0*b1*c1*d1
a1*b0*c0*d0
a1*b0*c0*d1
a1*b0*c1*d0
a1*b0*c1*d1
a1*b1*c0*d0
a1*b1*c0*d1
a1*b1*c1*d0
a1*b1*c1*d1

} → qf(qx)

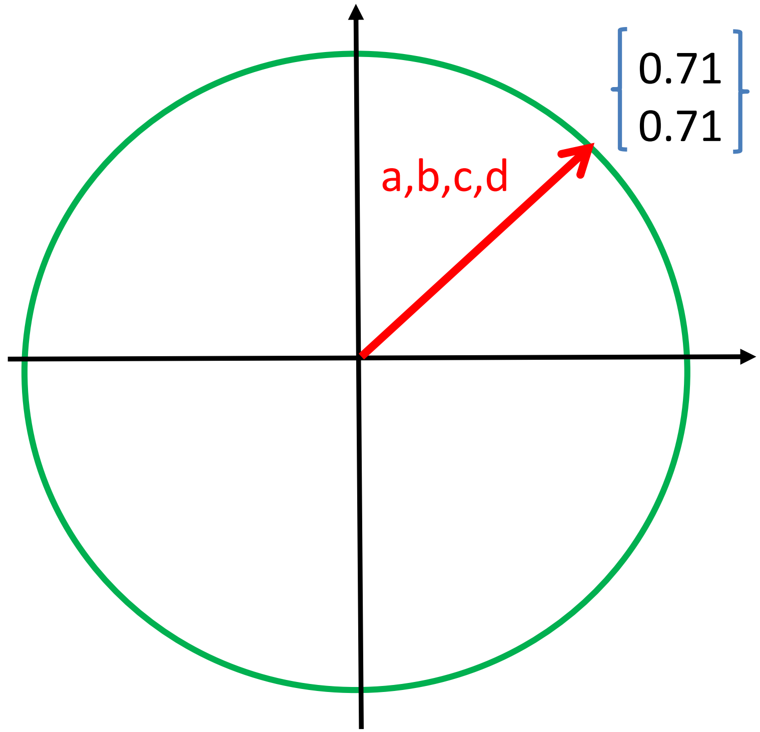


a

b

c

d



abcd	
0	0.25
1	0.25
2	0.25
3	0.25
4	0.25
5	0.25
6	0.25
7	0.25
8	0.25
9	0.25
10	0.25
11	0.25
12	0.25
13	0.25
14	0.25
15	0.25

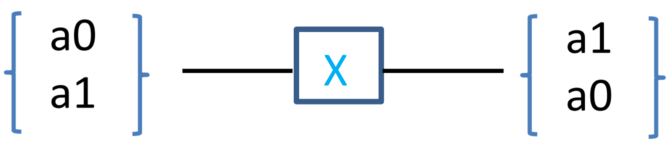
Operations on Qubits

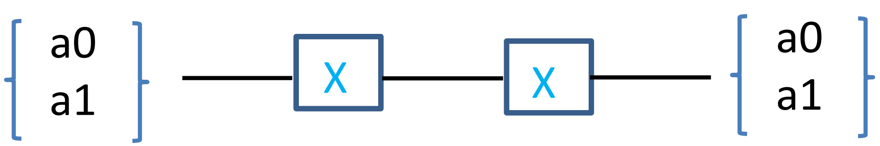
$$/a> = \begin{bmatrix} a0 \\ a1 \end{bmatrix} \qquad X = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}$$

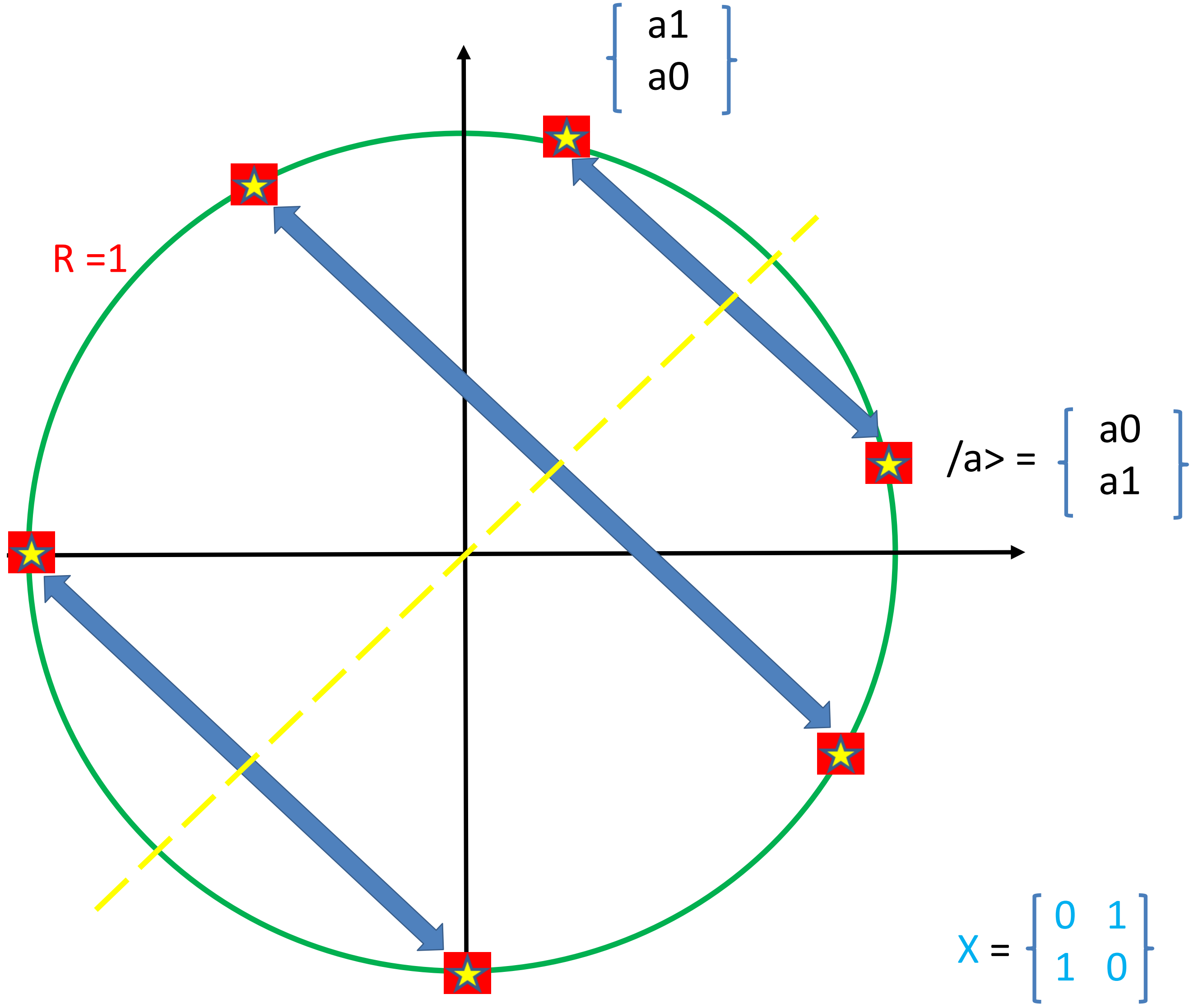
X GATE, NOT GATE, INVERTER GATE

$X * /a> = ?$

$$\begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix} \begin{bmatrix} a0 \\ a1 \end{bmatrix} = \begin{bmatrix} a1 \\ a0 \end{bmatrix}$$





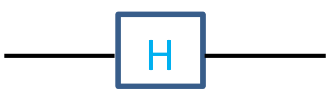

a1
a0
R =1
/a> =
a0
a1
X =
0 1
1 0

$$/a> = \begin{bmatrix} a0 \\ a1 \end{bmatrix} \qquad H = \frac{\sqrt{2}}{2}\begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$$

H GATE, HADAMARD GATE

$$H * /a> = ? \qquad \frac{\sqrt{2}}{2}\begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}\begin{bmatrix} a0 \\ a1 \end{bmatrix} = \frac{\sqrt{2}}{2}\begin{bmatrix} a0 + a1 \\ a0 - a1 \end{bmatrix}$$

$$\begin{bmatrix} a0 \\ a1 \end{bmatrix}$$



$$\frac{\sqrt{2}}{2}\begin{bmatrix} a0 + a1 \\ a0 - a1 \end{bmatrix}$$

$$\begin{bmatrix} a0 \\ a1 \end{bmatrix}$$

$$\begin{bmatrix} a0 \\ a1 \end{bmatrix}$$

$$/ab> = \begin{bmatrix} a0*b0 \\ a0*b1 \\ a1*b0 \\ a1*b1 \end{bmatrix}$$

$$CNOT = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

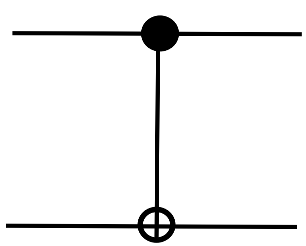
CONDITIONAL X GATE

CNOT * /ab> = ?

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} a0*b0 \\ a0*b1 \\ a1*b0 \\ a1*b1 \end{bmatrix} = \begin{bmatrix} a0*b0 \\ a0*b1 \\ a1*b1 \\ a1*b0 \end{bmatrix}$$

$$\begin{bmatrix} a0 \\ a1 \end{bmatrix}$$

$$\begin{bmatrix} b0 \\ b1 \end{bmatrix}$$



$$\begin{bmatrix} a0 \\ a1 \end{bmatrix}$$

$$\begin{bmatrix} b0 \\ b1 \end{bmatrix}$$ When a1 = 0

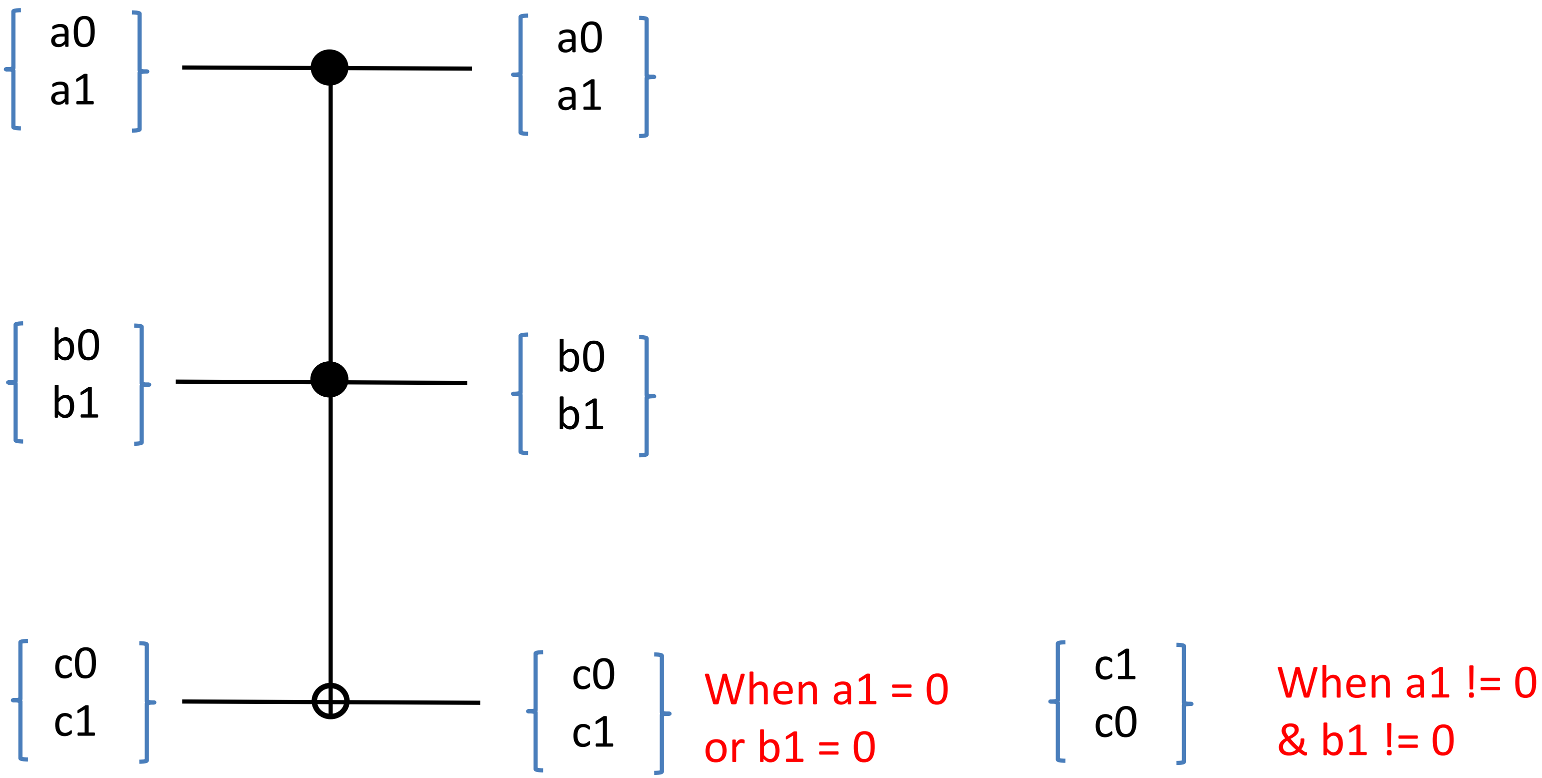
$$\begin{bmatrix} b1 \\ b0 \end{bmatrix}$$ When a1 != 0

$$/abc> = \begin{bmatrix} a0b0c0 \\ a0b0c1 \\ a0b1c0 \\ a0b1c1 \\ a1b0c0 \\ a1b0c1 \\ a1b1c0 \\ a1b1c1 \end{bmatrix} \quad CCNOT = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \end{bmatrix}$$

CONDITIONAL,
CONDITIONAL X GATE

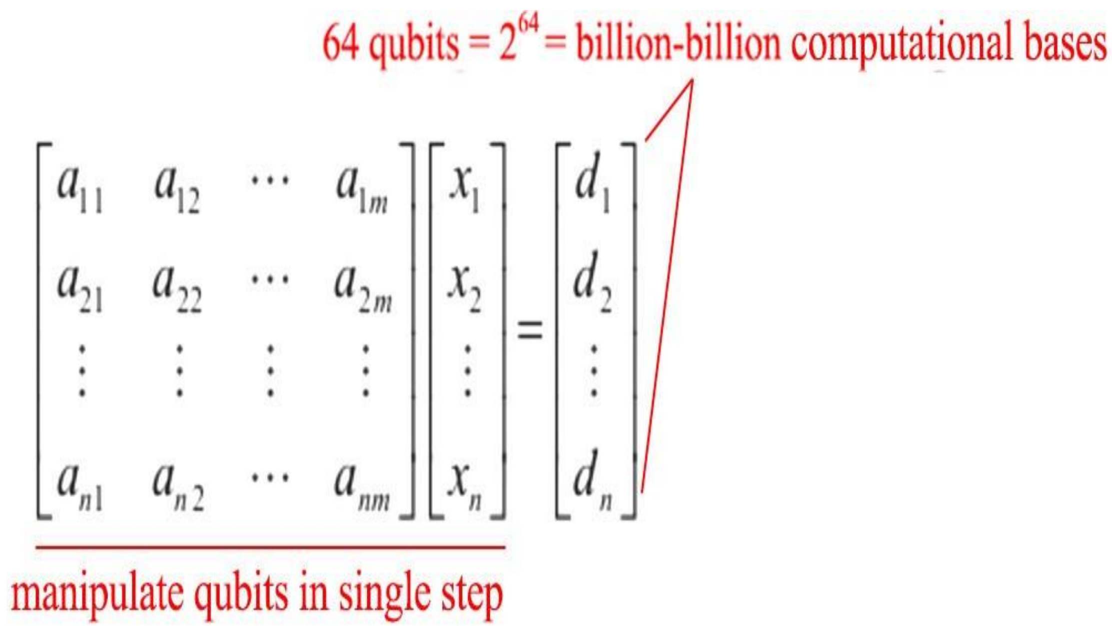
CCNOT * /abc> = ?

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} a0b0c0 \\ a0b0c1 \\ a0b1c0 \\ a0b1c1 \\ a1b0c0 \\ a1b0c1 \\ a1b1c0 \\ a1b1c1 \end{bmatrix} = \begin{bmatrix} a0b0c0 \\ a0b0c1 \\ a0b1c0 \\ a0b1c1 \\ a1b0c0 \\ a1b0c1 \\ a1b1c1 \\ a1b1c0 \end{bmatrix}$$

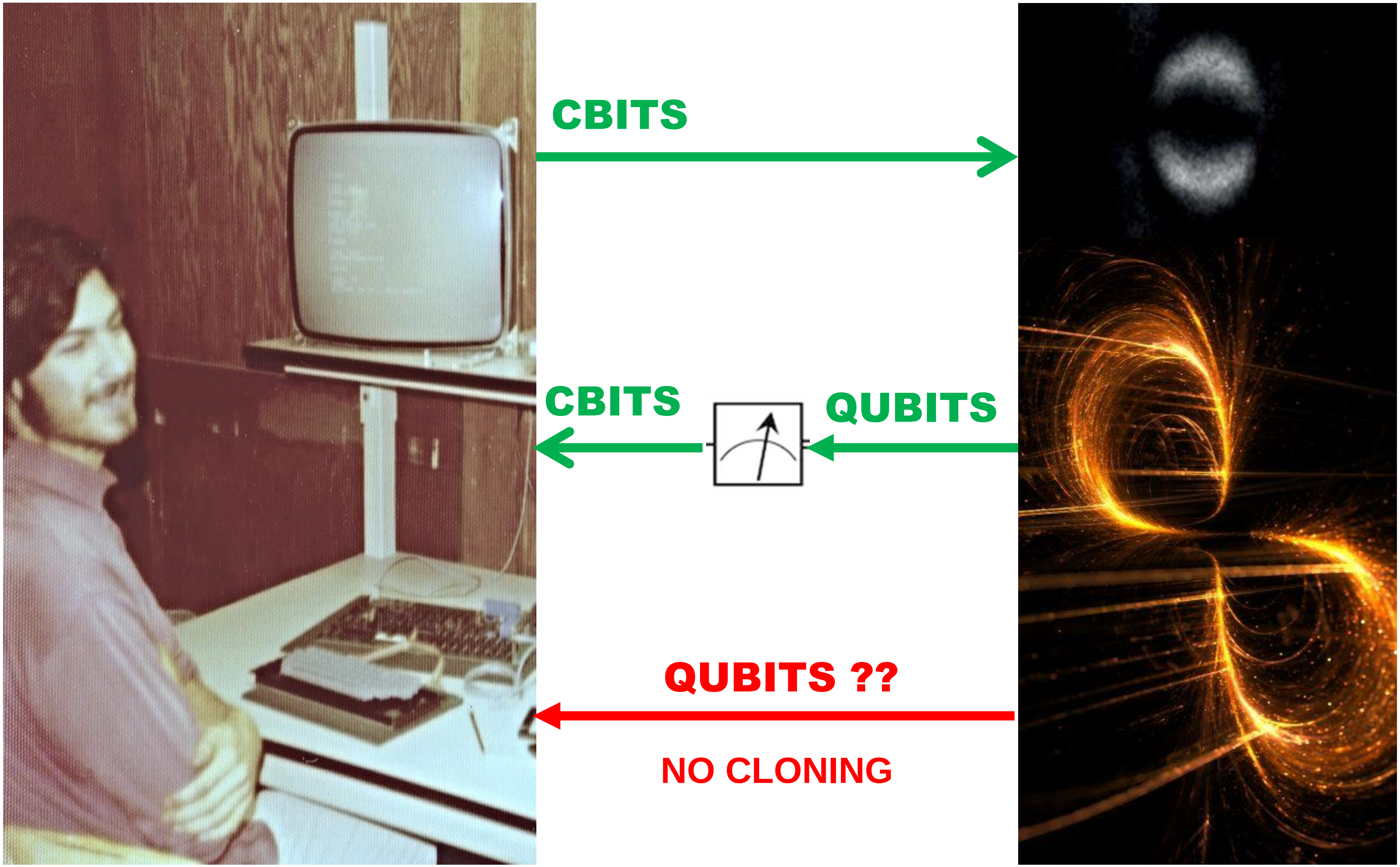

a0
a1
b0
b1
c0
c1
a0
a1
b0
b1
c0
c1
When a1 = 0
or b1 = 0
c1
c0
When a1 != 0
& b1 != 0

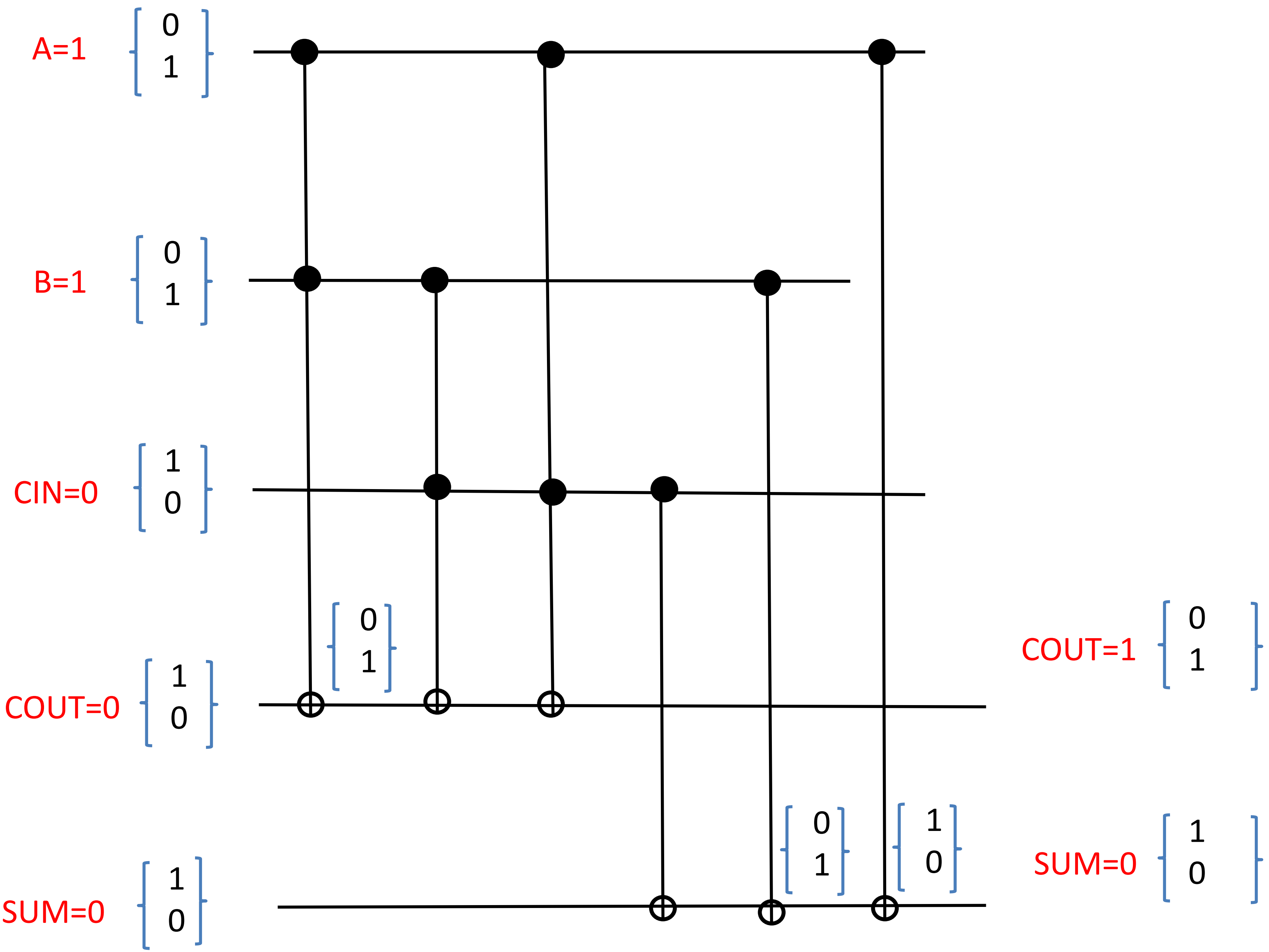
Quantum Parallelism

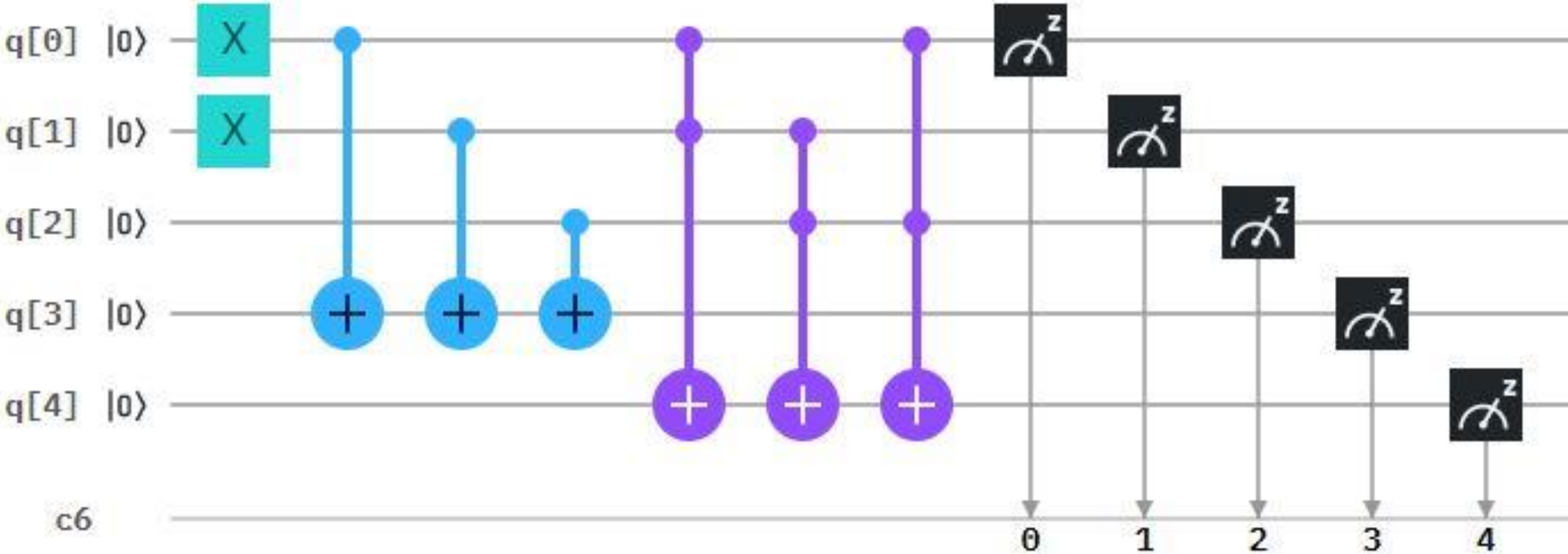
The power of quantum parallelism can be summarized in the following matrix. We apply a unitary operation to manipulate qubit(s) in one step (in practice, polynomial steps).
Since the number of components in the computational basis increases exponentially with the number of qubits, the quantum parallelism offers a possibility of computing *f(x)* with all valid values of *x* simultaneously.

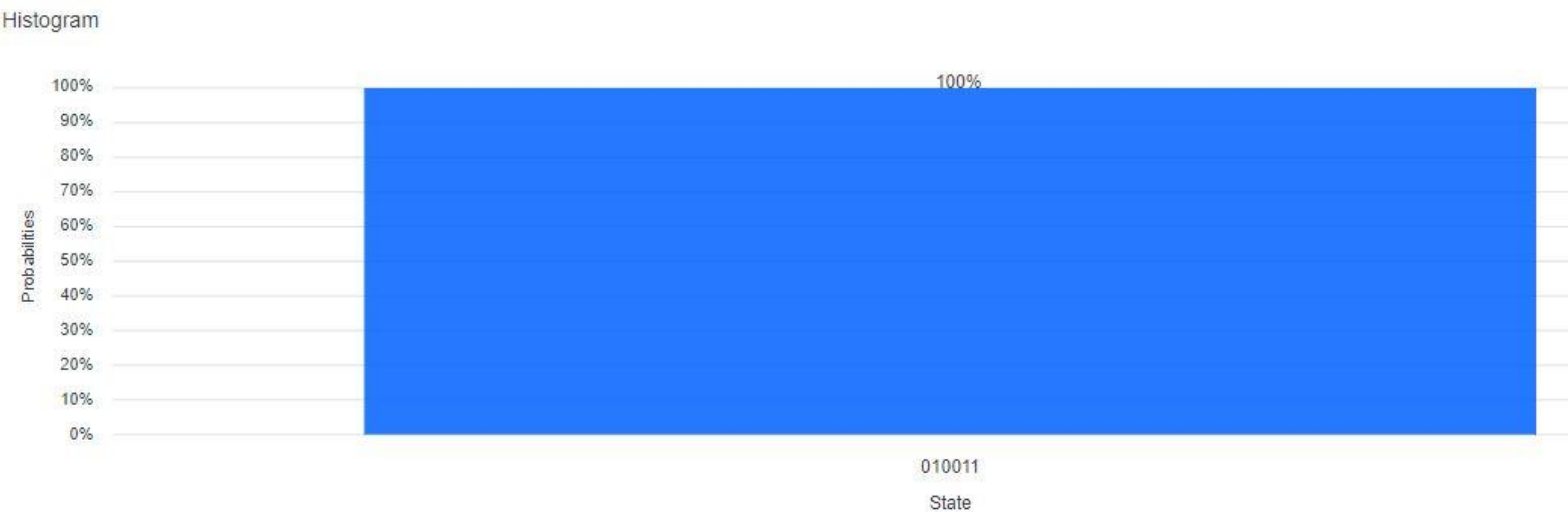


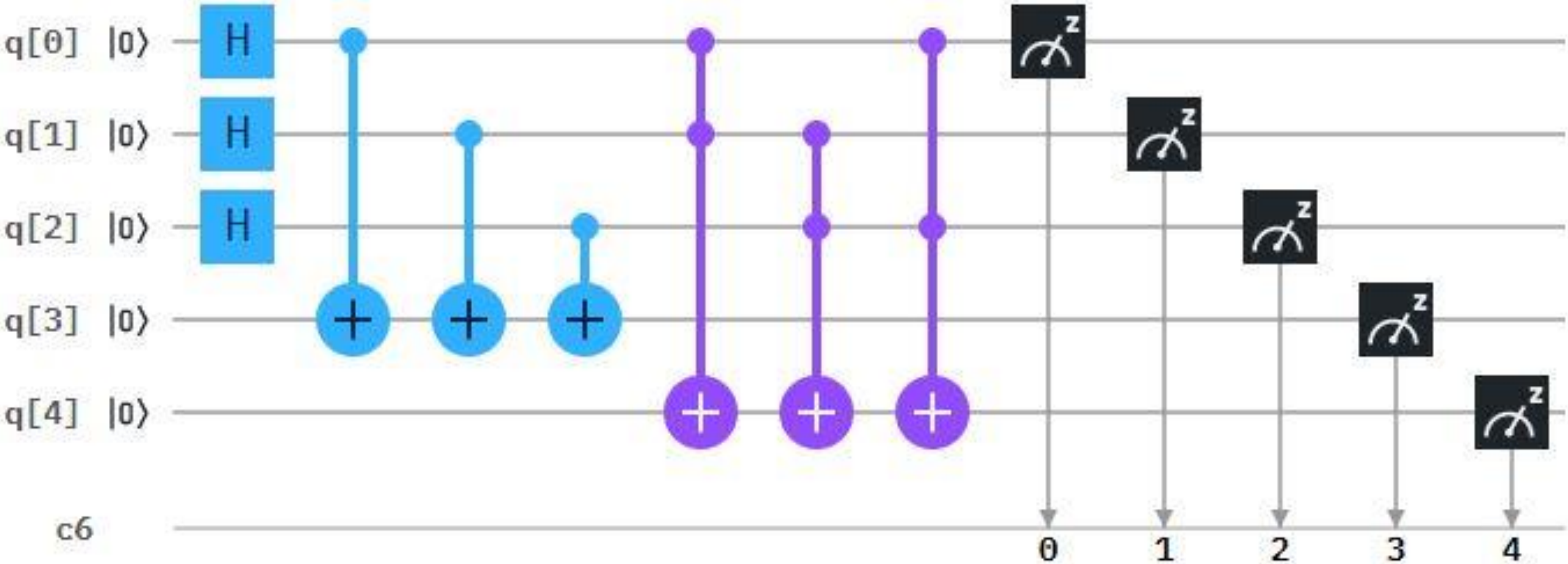
CLASSICAL BITS **QUBITS**



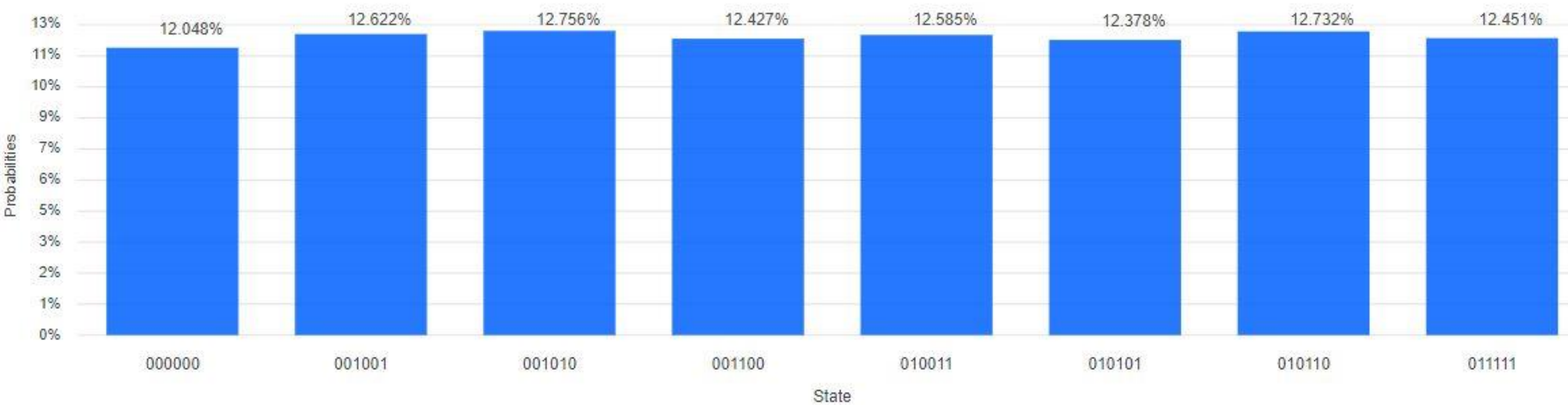

A=1
0
1
B=1
0
1
CIN=0
1
0
COUT=0
1
0
0
1
SUM=0
1
0
0
1
1
0
COUT=1
0
1
SUM=0
1
0


q[0] |0⟩
q[1] |0⟩
q[2] |0⟩
q[3] |0⟩
q[4] |0⟩
X
X
c6
0
1
2
3
4

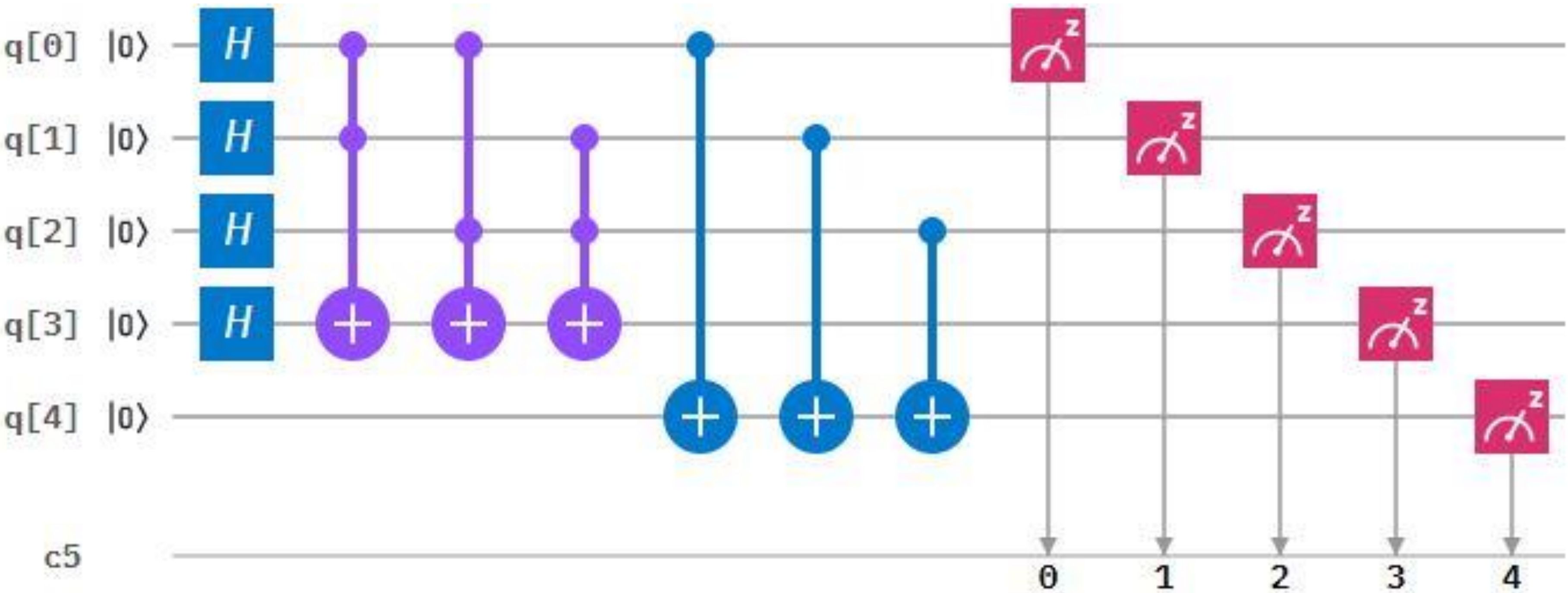

Histogram
100%
Probabilities
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
010011
State

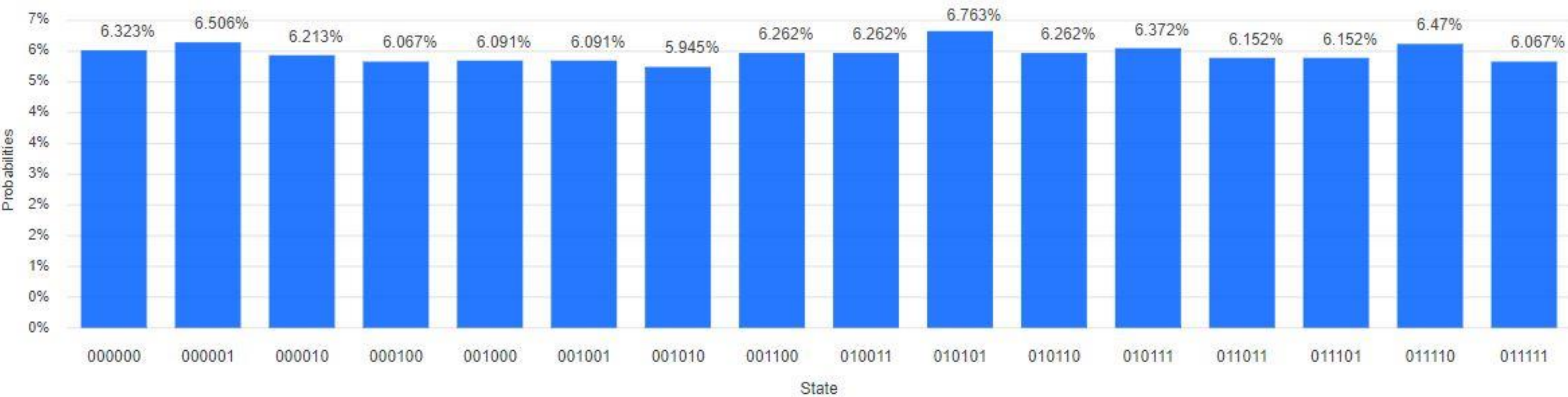


q[0] |0⟩
q[1] |0⟩
q[2] |0⟩
q[3] |0⟩
q[4] |0⟩
H
H
H
z
c6
0
1
2
3
4



Probabilities
13%
11%
10%
9%
7%
6%
5%
3%
2%
1%
0%
12.048%
12.622%
12.756%
12.427%
12.585%
12.378%
12.732%
12.451%
000000
001001
001010
001100
010011
010101
010110
011111
State


q[0] |0⟩
q[1] |0⟩
q[2] |0⟩
q[3] |0⟩
q[4] |0⟩
H
H
H
H
c5
0
1
2
3
4

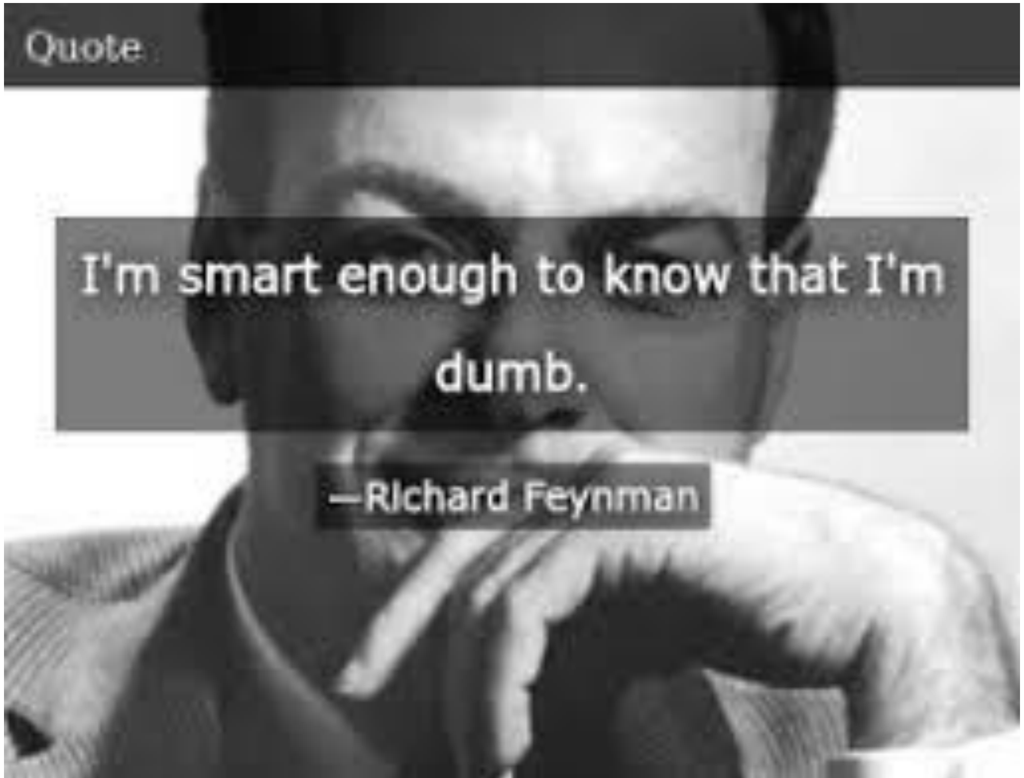

7%
6%
5%
4%
4%
3%
2%
2%
1%
0%
0%
Probabilities
6.323%
6.506%
6.213%
6.067%
6.091%
6.091%
5.945%
6.262%
6.262%
6.763%
6.262%
6.372%
6.152%
6.152%
6.47%
6.067%
000000
000001
000010
000100
001000
001001
001010
001100
010011
010101
010110
010111
011011
011101
011110
011111
State

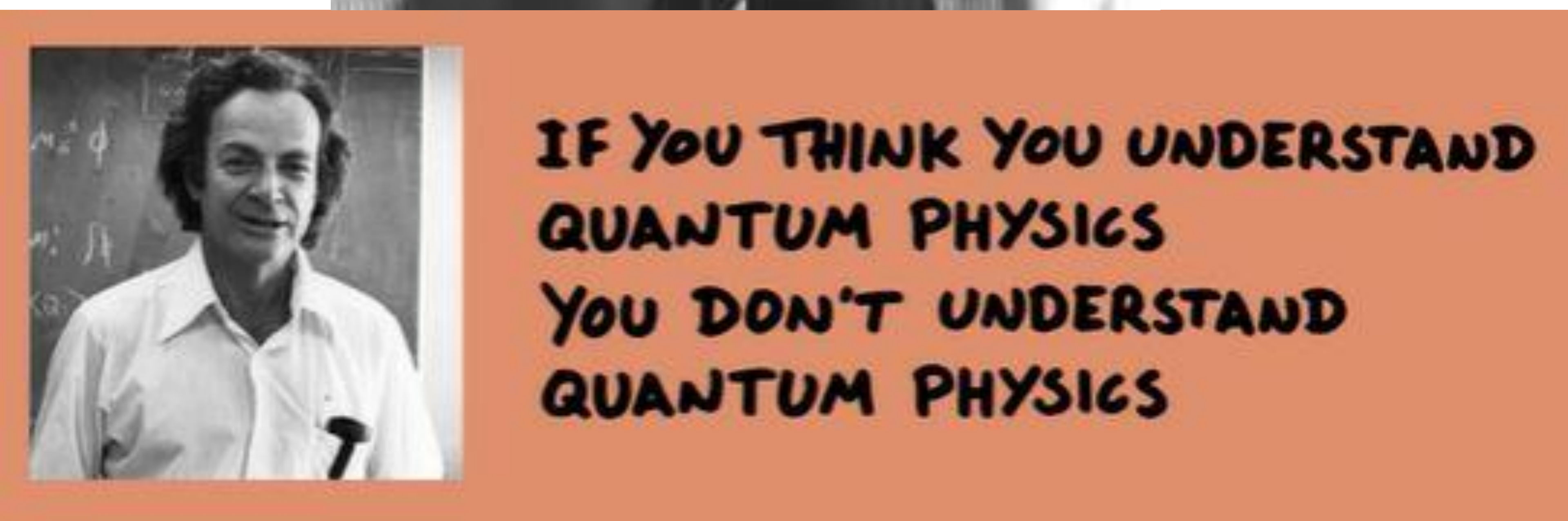
Qubit Communication

Andrea Morello at the University of New South Wales in Australia and his colleagues have a new design for a qubit. It uses both the nucleus and the electron of a phosphorus atom to create a single qubit inside a layer of silicon.

Qubits in silicon systems interact through electric fields, and Morello's team shows that it's possible to extend the reach of those electric fields by pulling the electron further away from the nucleus of each atom.

By combining an electron and nucleus into one qubit, Morello and his team think they've found a way to let qubits communicate over distances of up to 500 nanometers. This could eventually make it possible to create quantum computers with millions of qubits that can simulate simple chemical reactions.


Quote
I'm smart enough to know that I'm dumb.
—Richard Feynman


IF YOU THINK YOU UNDERSTAND QUANTUM PHYSICS YOU DON'T UNDERSTAND QUANTUM PHYSICS

IBM Quantum computers:

https://quantum-computing.ibm.com/

3 Quantum Algorithms:

https://www.nap.edu/read/25196/chapter/5

Interesting youtube:

https://www.youtube.com/watch?v=9blfVmrfruE&list=PL50XnIfJxPDVFftJn9hk0uj3QBuXag5ph&index=4&t=0s&app=desktop

https://www.youtube.com/watch?v=BcsdCMix1ns