



**leti**  
cea tech

**Research Tracks  
To Guide the ICT Industry  
Toward Greener Electronics**

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Created in **1967** in Grenoble, France  
**2,000** people in 2021



**3,000+** patents in portfolio  
**70** startups created over 20 years  
**3,500** new jobs



**500** state-of-the-art tools  
**11,000 m<sup>2</sup>** of cleanroom space



2010-2020:

> A data-driven era



Mobile data

**+20316%**



Internet traffic

**+1170%**



Electricity

**+22%**



Internet users

**+125%**



World population

**+10%**

# DIGITALIZATION

> Providing great new services

Smart home



Smart cities



Agriculture



Health



Factories



Energy networks



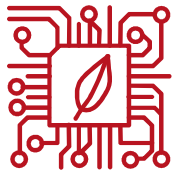
**60B**

**connected objects  
by 2030  
using embedded  
computing**

## FACING GLOBAL DIGITALIZATION



**Digitalization is accelerating and bringing new useful services**



Major show-stoppers:

- **Energy efficiency**
- **Sustainable electronics**



**Breakthrough innovations are necessary:**

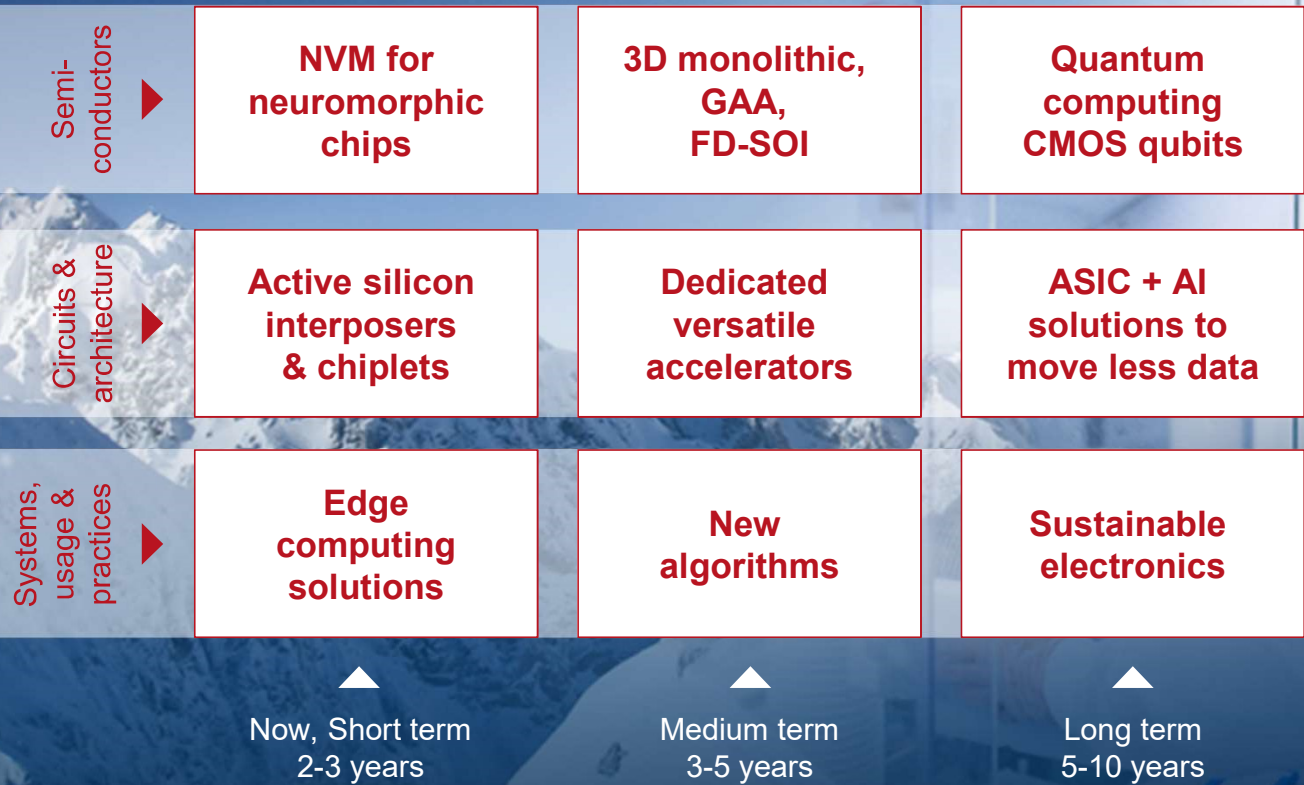
- In Semiconductor technologies
- In Circuits and architectures
- In Systems, usage and practices

Improve  
energy efficiency

**× 1000**

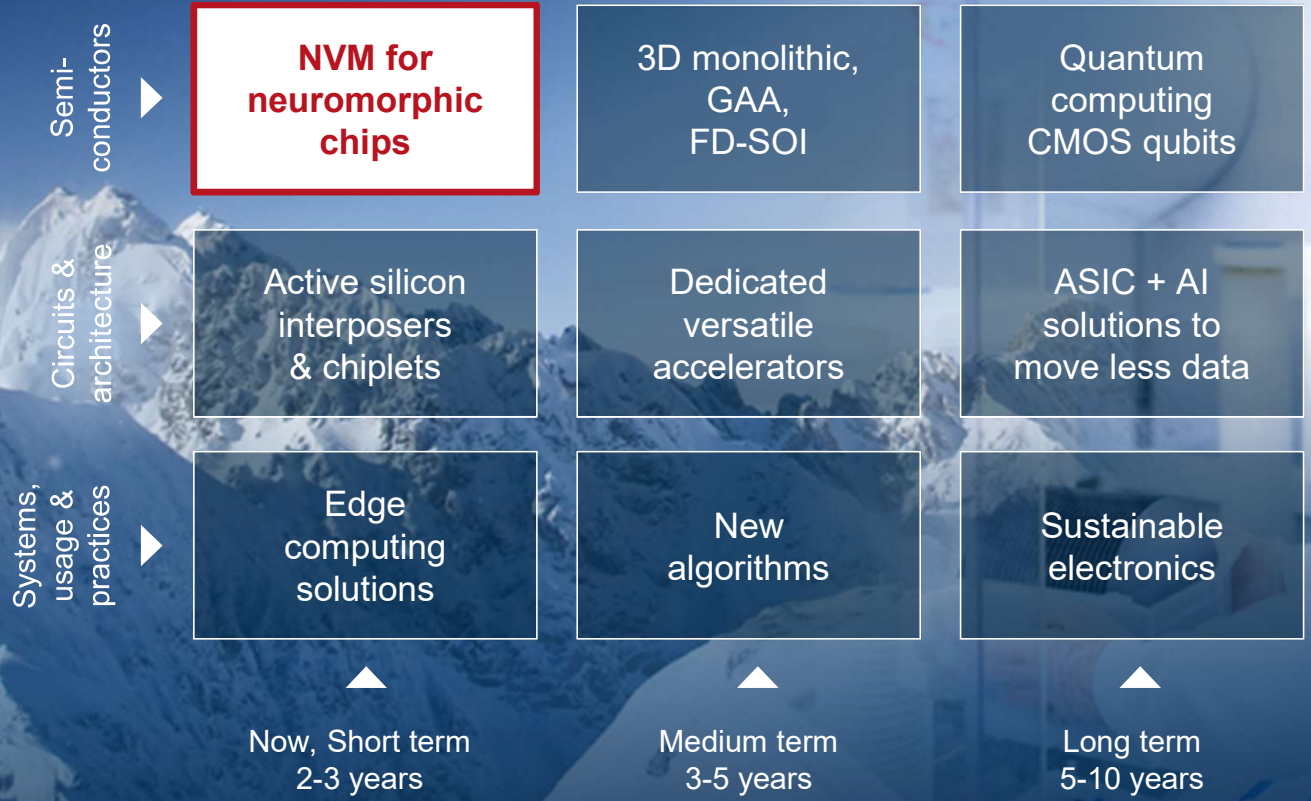
by 2030

# 9 RESEARCH TRACKS



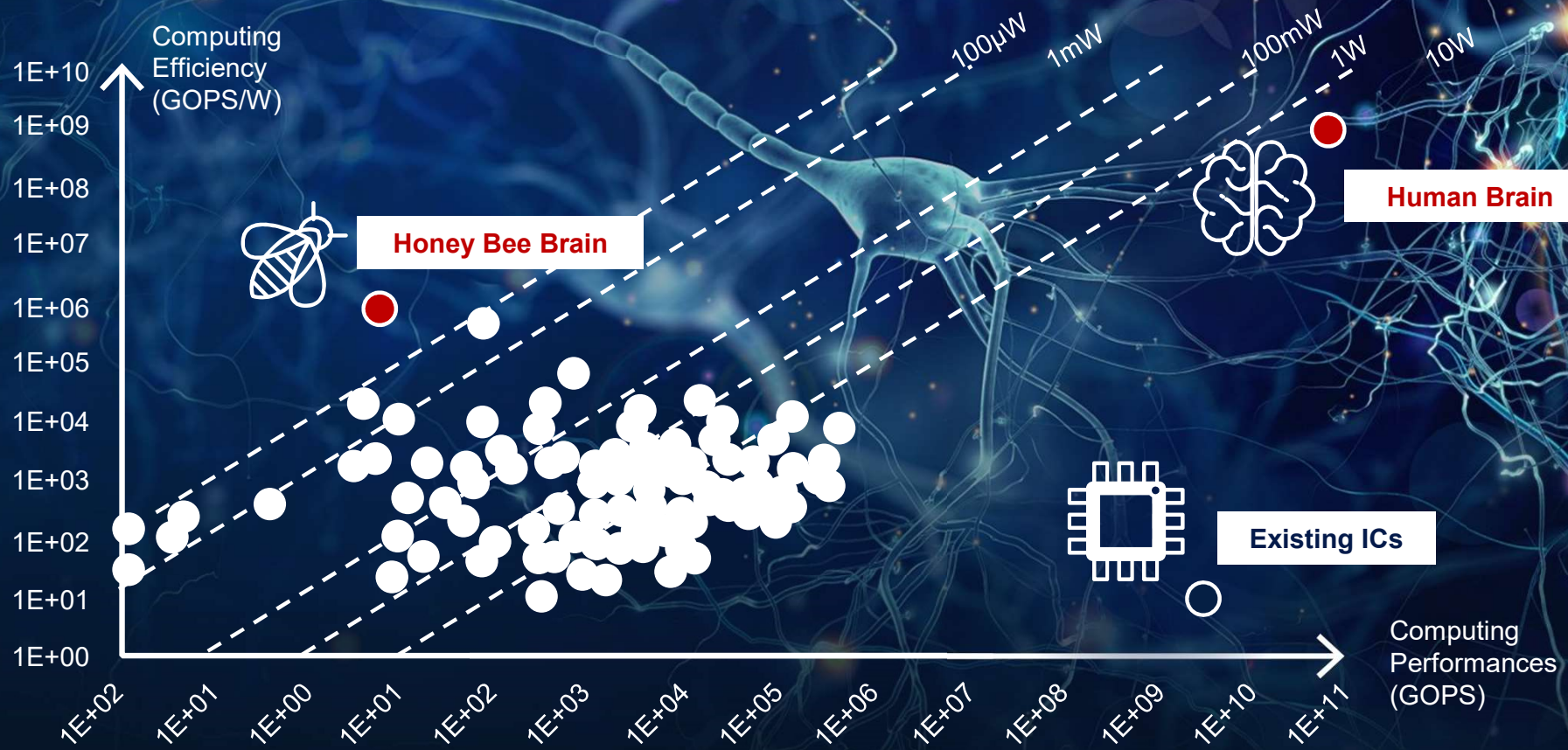
# 9 RESEARCH TRACKS

> Improve energy efficiency  $\times 1000$



# NATURE

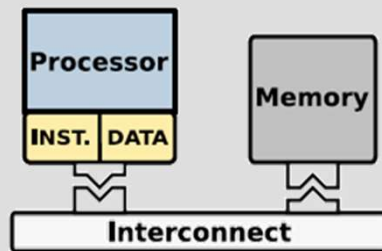
> A source of inspiration for semiconductors





# MEMORY IS CRITICAL TO MEET THE ENERGY CHALLENGE

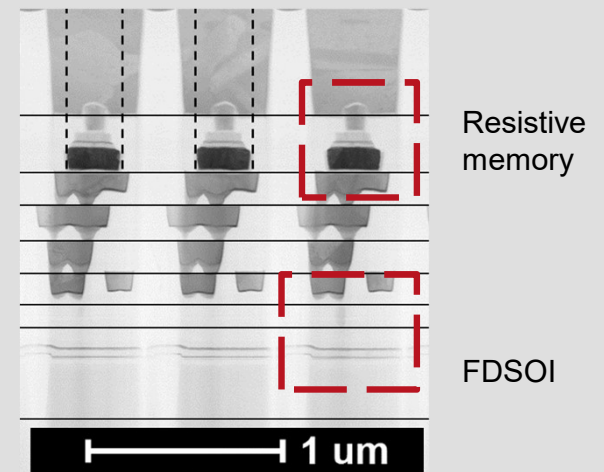
## How data consumes energy



Operation	Energy
Addition of data (fixed point)	1×
Accessing data (onchip cache)	60×
Accessing data (offchip RAM)	3500×

Data movement between storage and processing units can reach **90% of the overall energy consumption**

## Non-volatile memories



**Need for high density on-chip resistive memories**

## DIFFERENT TYPES OF MEMORIES

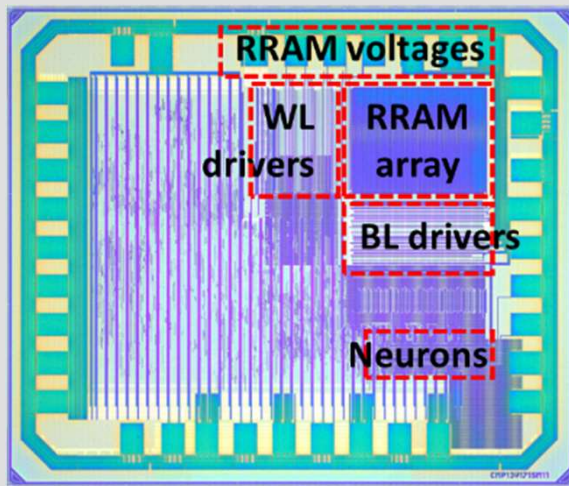
Programming power  
reduction  $\times 20,000$

	FLASH	ReRAM (HfO <sub>2</sub> )	FeRAM (HfO <sub>2</sub> )
Programming power	<b>~200pJ/bit</b>	~100pJ/bit	<b>~10fJ/bit</b>
Write speed	20 $\mu$ s	10-100 ns	14ns @ 2.5V
Endurance	10 <sup>5</sup> - 10 <sup>6</sup>	10 <sup>5</sup> - 10 <sup>6</sup>	<b>&gt; 10<sup>11</sup></b>
Retention	> 125°C	> 125°C	85°C
Extra masks	Very high (>10)	Low (2)	Low (2)

# NEUROMORPHIC CHIPS

> Improve energy efficiency  $\times 100+$

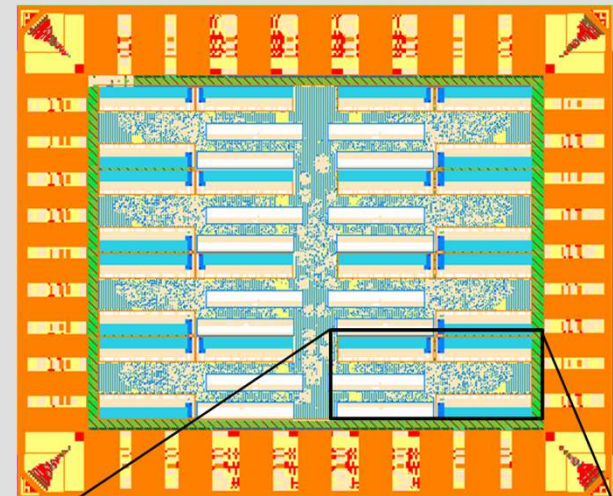
## SPIRIT



IE  
DM  
2019

CMOS node: 130nm  
10 neurons & 144 synapses  
3.6 pJ /spike

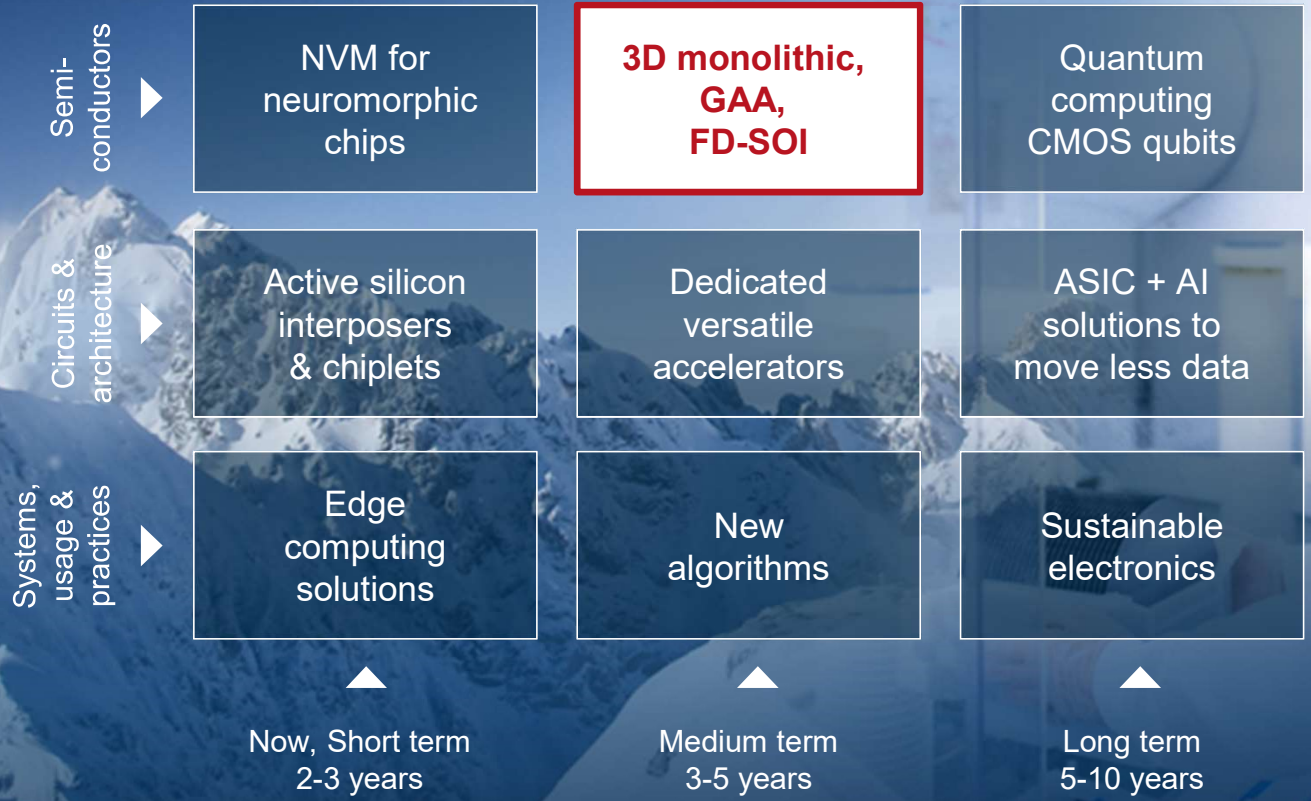
## LARGO



CMOS node: 28nm FD-SOI  
131k neurons & 75M synapses  
0.5pJ / spike

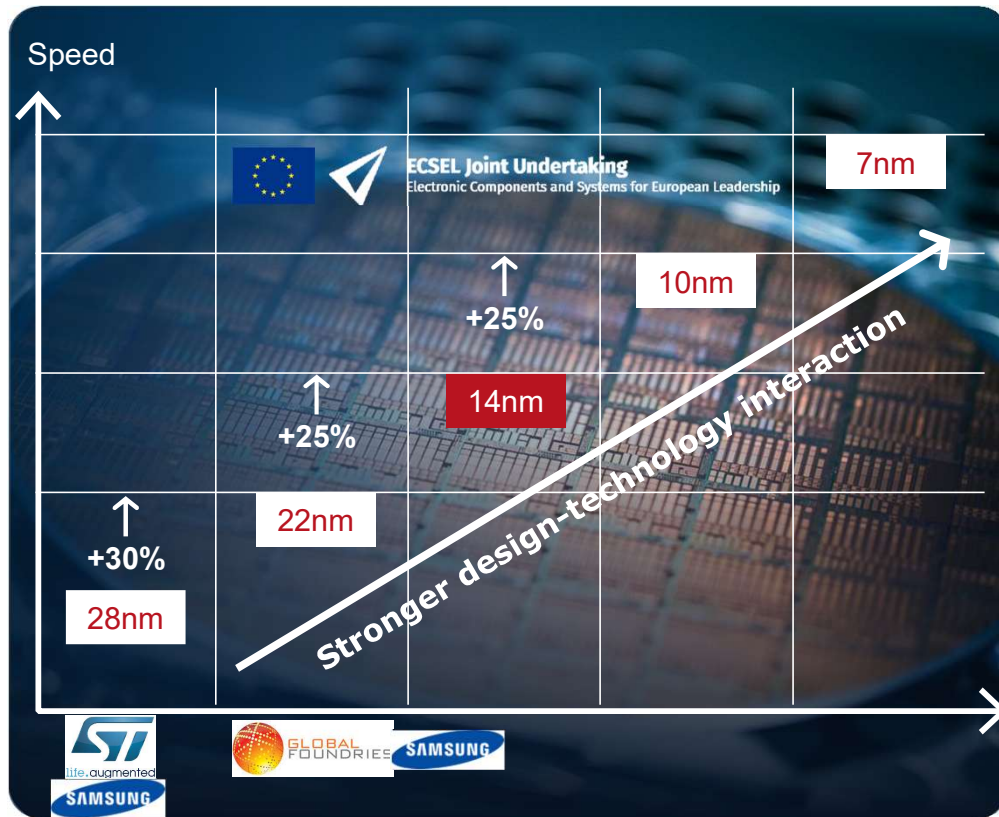
# 9 RESEARCH TRACKS

> Improve energy efficiency  $\times 1000$



# FD-SOI ROADMAP

> Developing 14nm, 10nm and beyond nodes

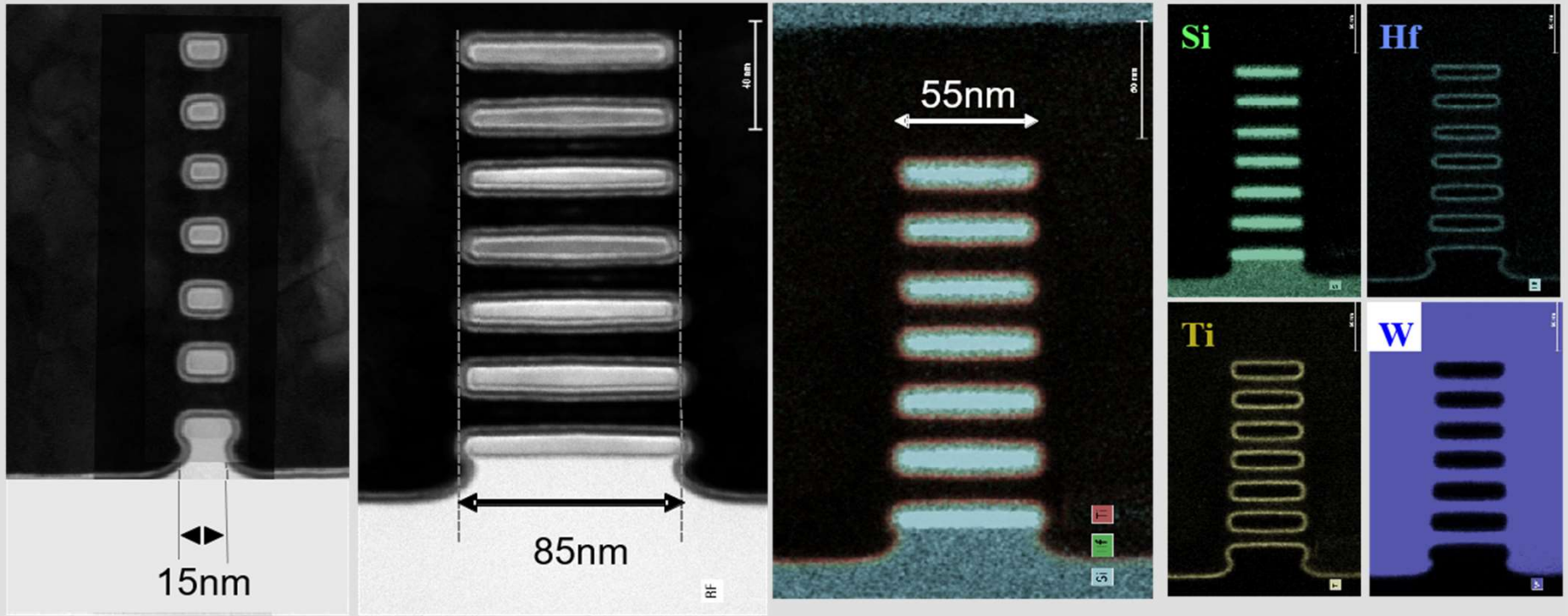


## Scaling the FD-SOI technology is becoming indispensable

- > ultra-low power IoT devices,
- > automotive,
- > RF,
- > Edge AI,
- > 5G-6G

# SILICON-BASED DEVICES (GAA)

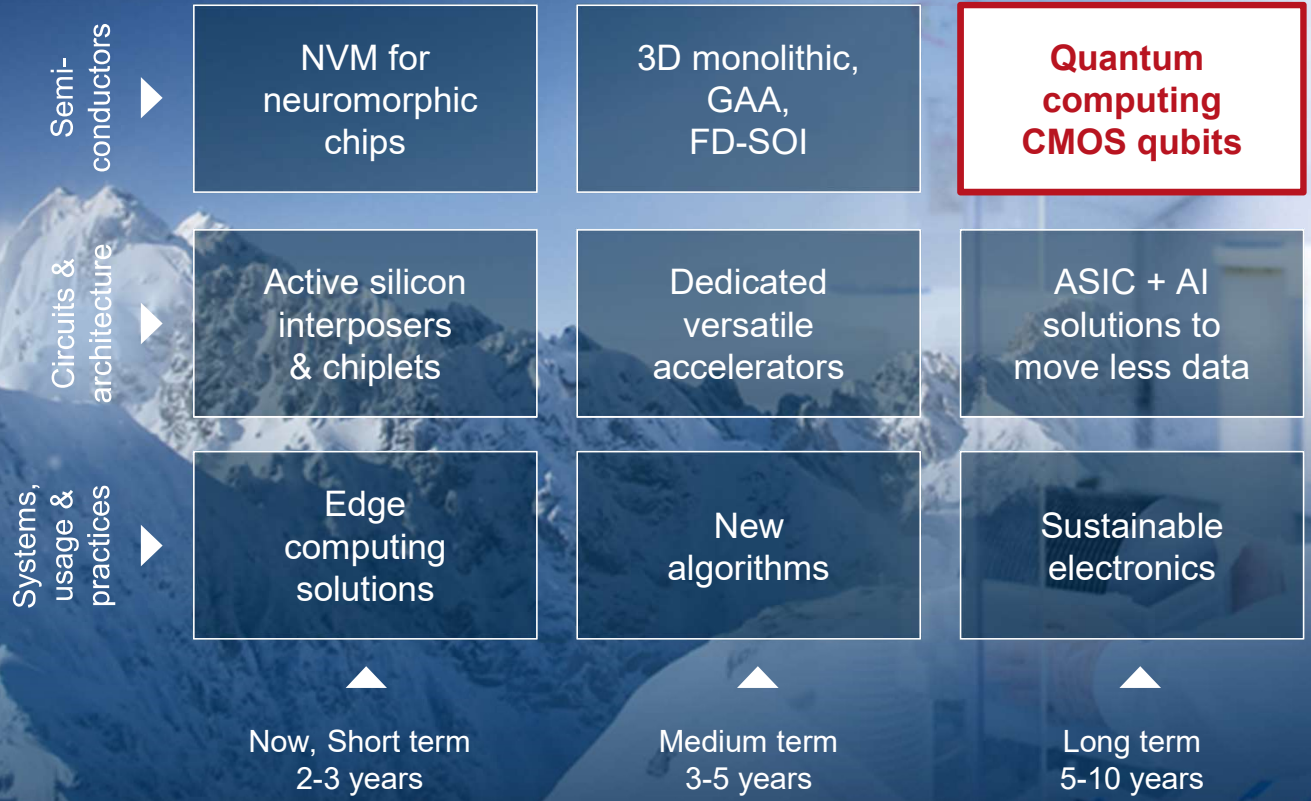
> Improve energy efficiency  $\times 2$



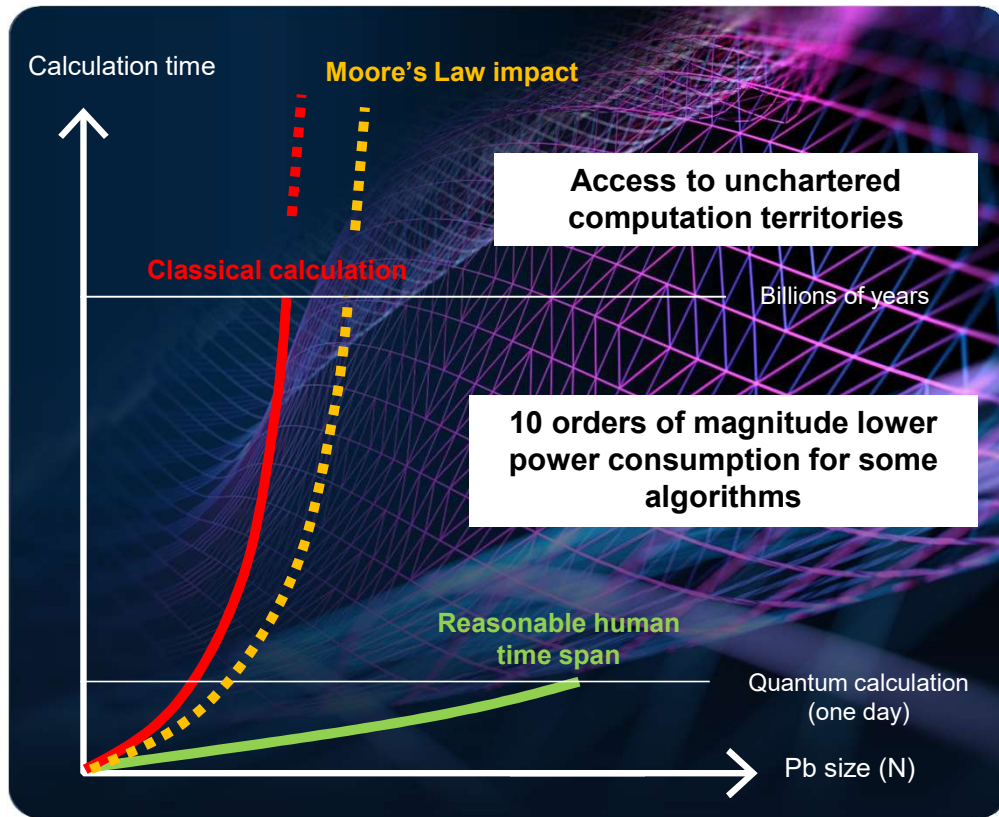
7 stacked nanosheets

# 9 RESEARCH TRACKS

> Improve energy efficiency  $\times 1000$



# QUANTUM COMPUTING PROMISES



## Transport & logistics

- > travel optimization
- > fleet management



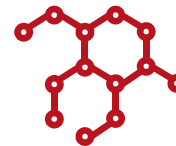
## Healthcare

- > molecular simulation
- > drug discovery



## Energy

- > management and optimization of renewable energies



## Manufacturing of New materials

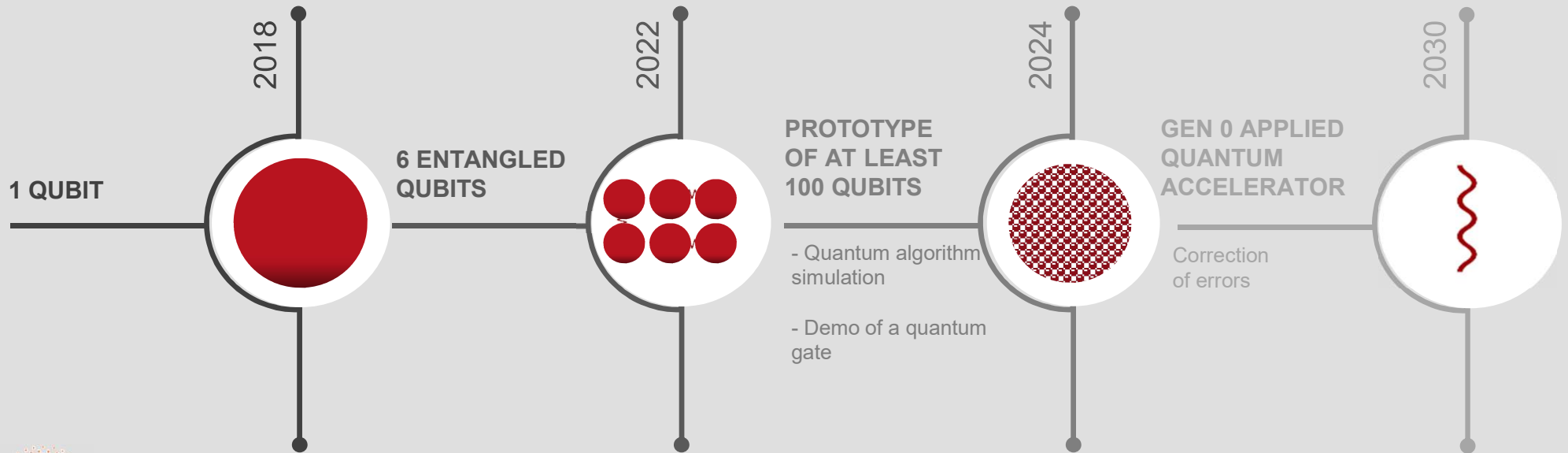


# SEVERAL TECHNOLOGIES STILL IN COMPETITION

	PHOTON	ELECTRONS				ATOMS	
	Photons	Super-conducting	Silicon	NV Centers	Majorana Fermions	Cold Atoms	Trapped Oons
Qubit size	$(100\mu\text{m})^2$	$(100\mu\text{m})^2$	$(100\text{nm})^2$			atomes	$(1\text{mm})^2$
Two gate fidelity	98%	99,4%	99,6%	92%		98%	99,9%
Readout fidelity	50%	95%	99%	93%		99%	99,9%
Speed	1ms	250 ns	$\approx 1\mu\text{s}$				100 $\mu\text{s}$
Temperature	4K/10K for photons generators and detectors	$\sim 15\text{mK}$	1K	300K	15mK	15mK	10K
Entangled qubits	70 (China)	65 (IBM & Google)	3 (Rikken)	6		196 (Pasqal)	14 (AQT)
Scalability	100s	100s	millions	100s		100s	100

# CEA-LETI'S QUANTUM ROADMAP

> Ambitious national research program launched by President Macron



2030

2025

2020

Improve  
energy efficiency

× 1000

**The Challenge: Capitalize on  
hardware and software advances  
to master global digitization  
and preserve the planet**



If you share  
the same vision,  
**Join us!**

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