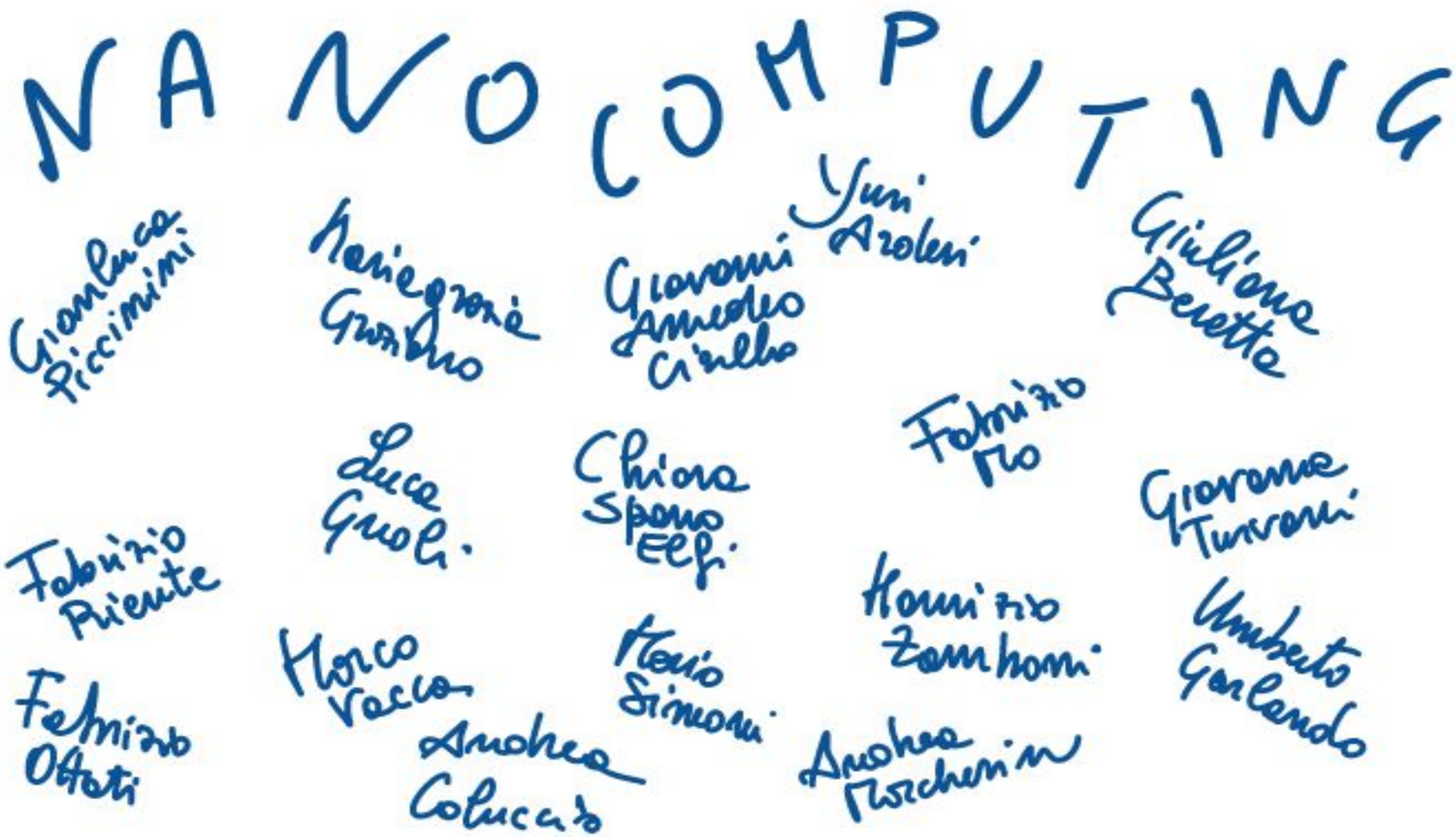
Master theses proposals

Update: December 2020

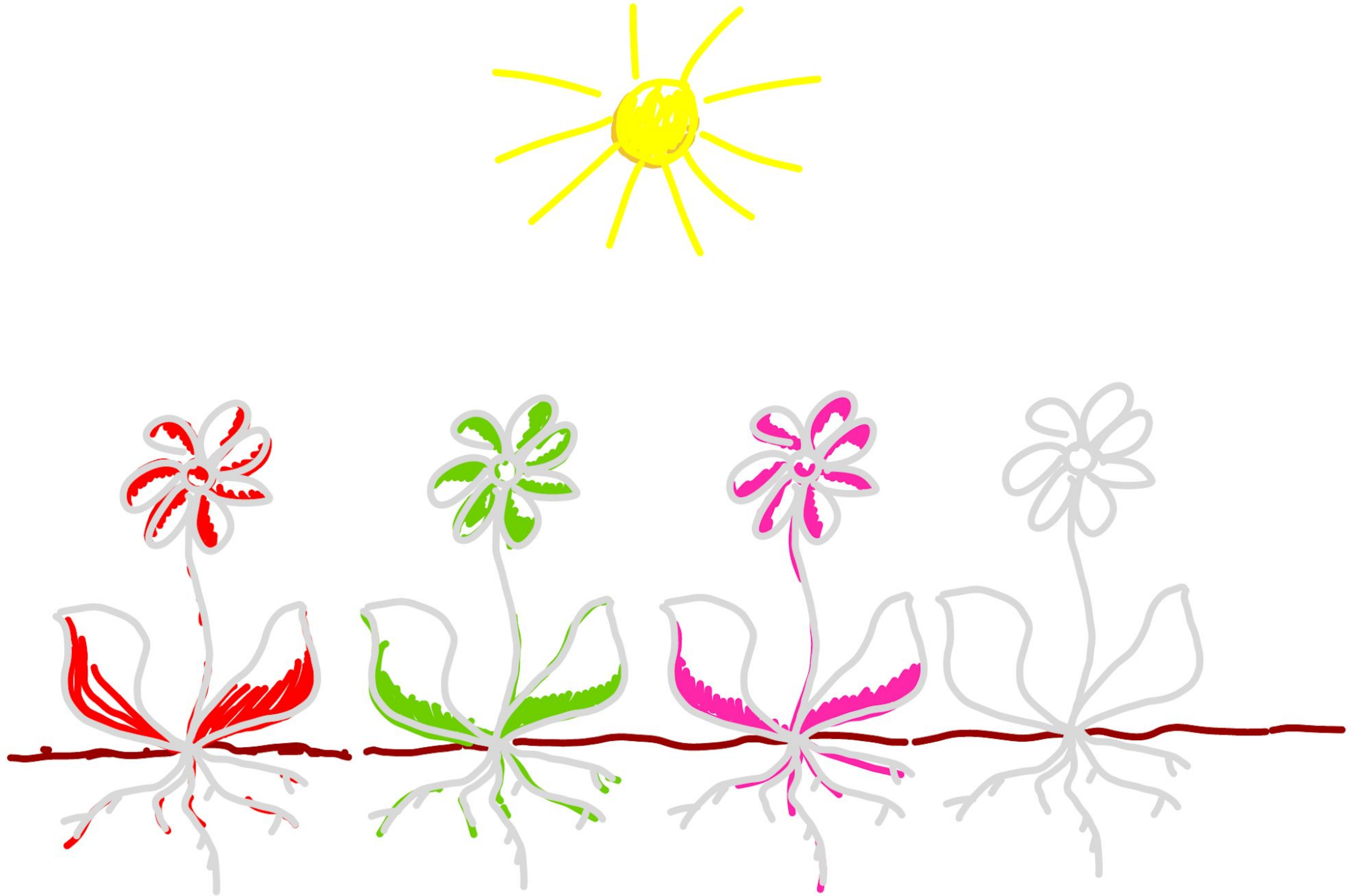


POLITECNICO DI TORINO

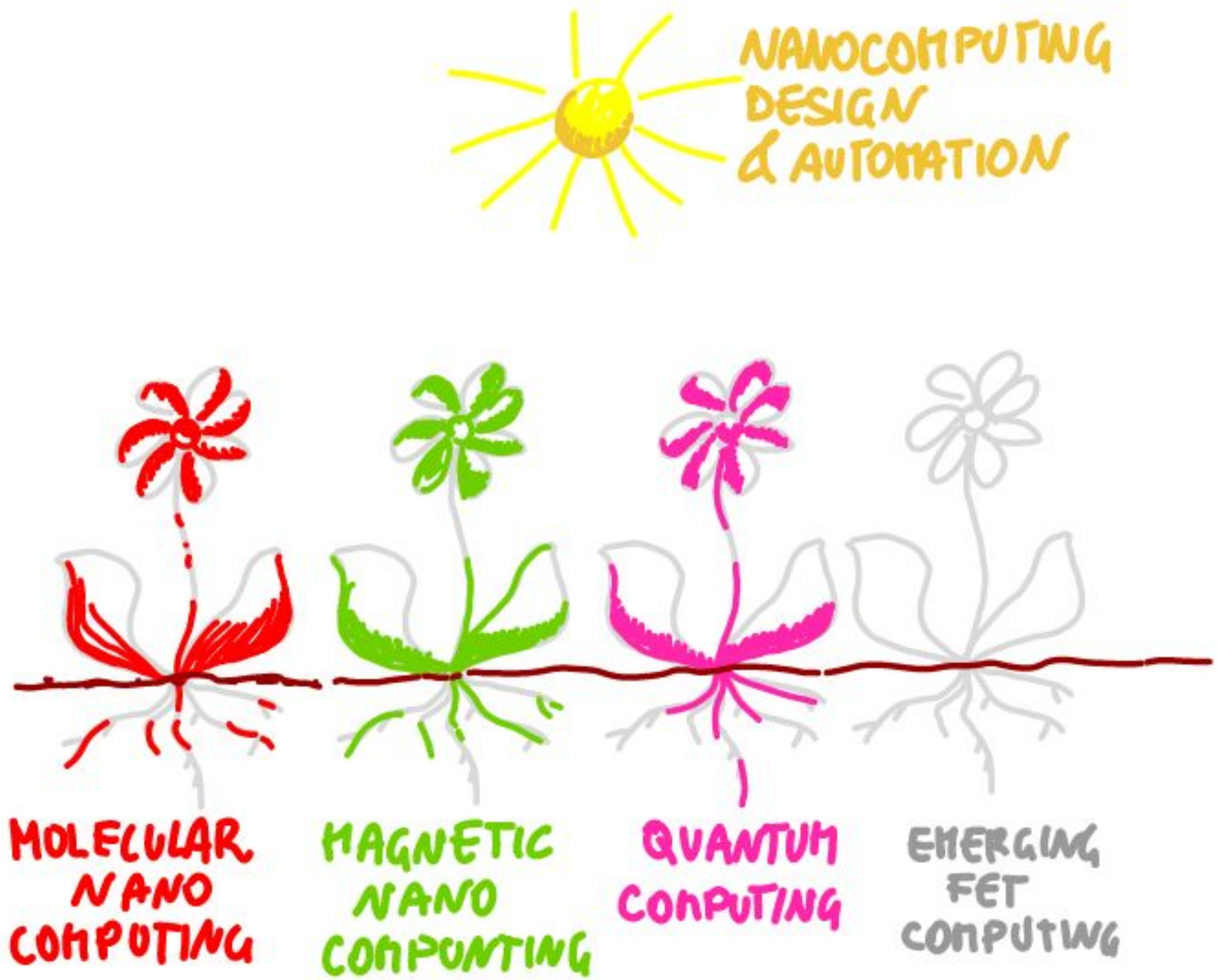
NANOCOMPUTING

Let’s draw a MAP in the NANOCOMPUTING garden

The NANOCOMPUTING garden



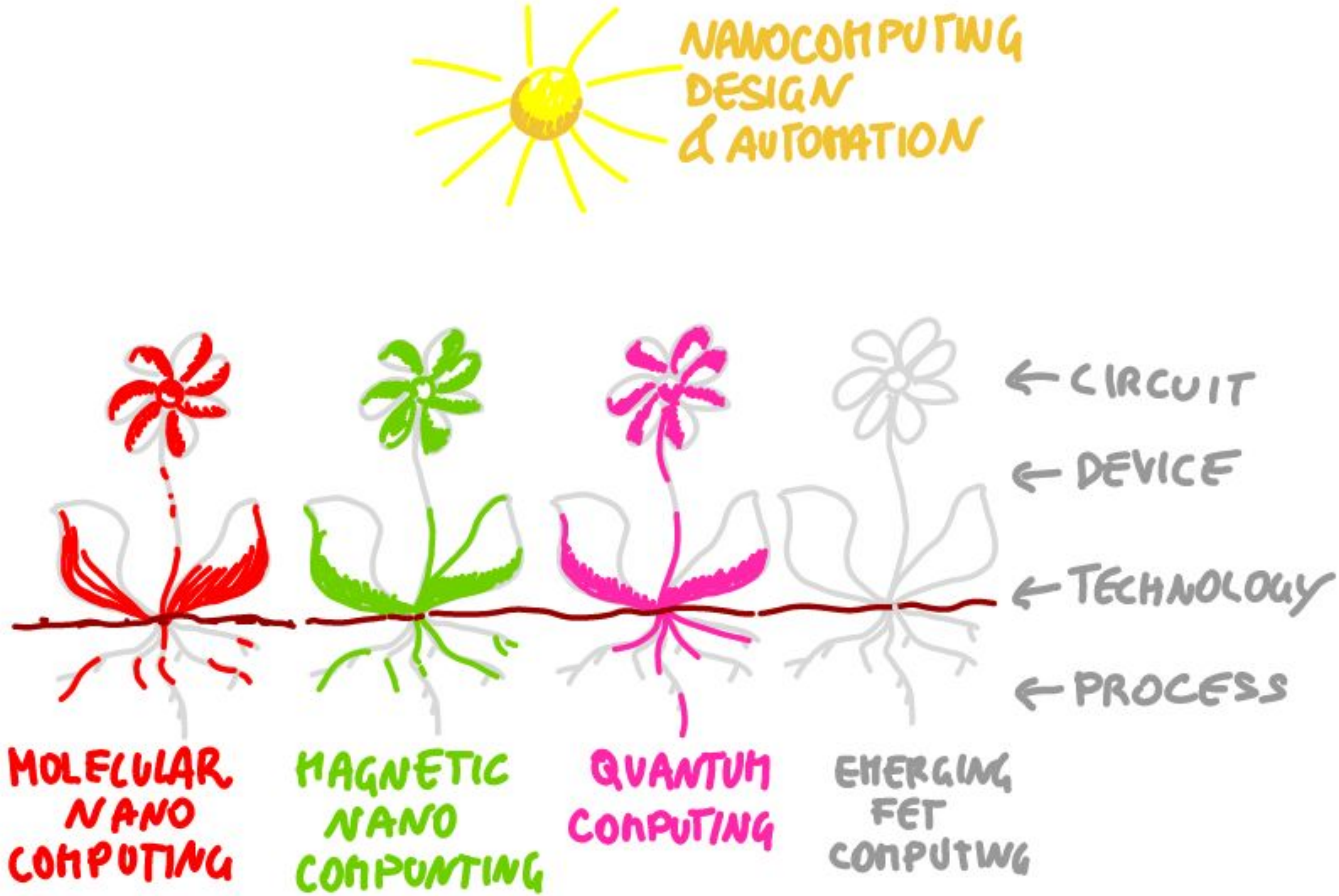
The NANOCOMPUTING elements



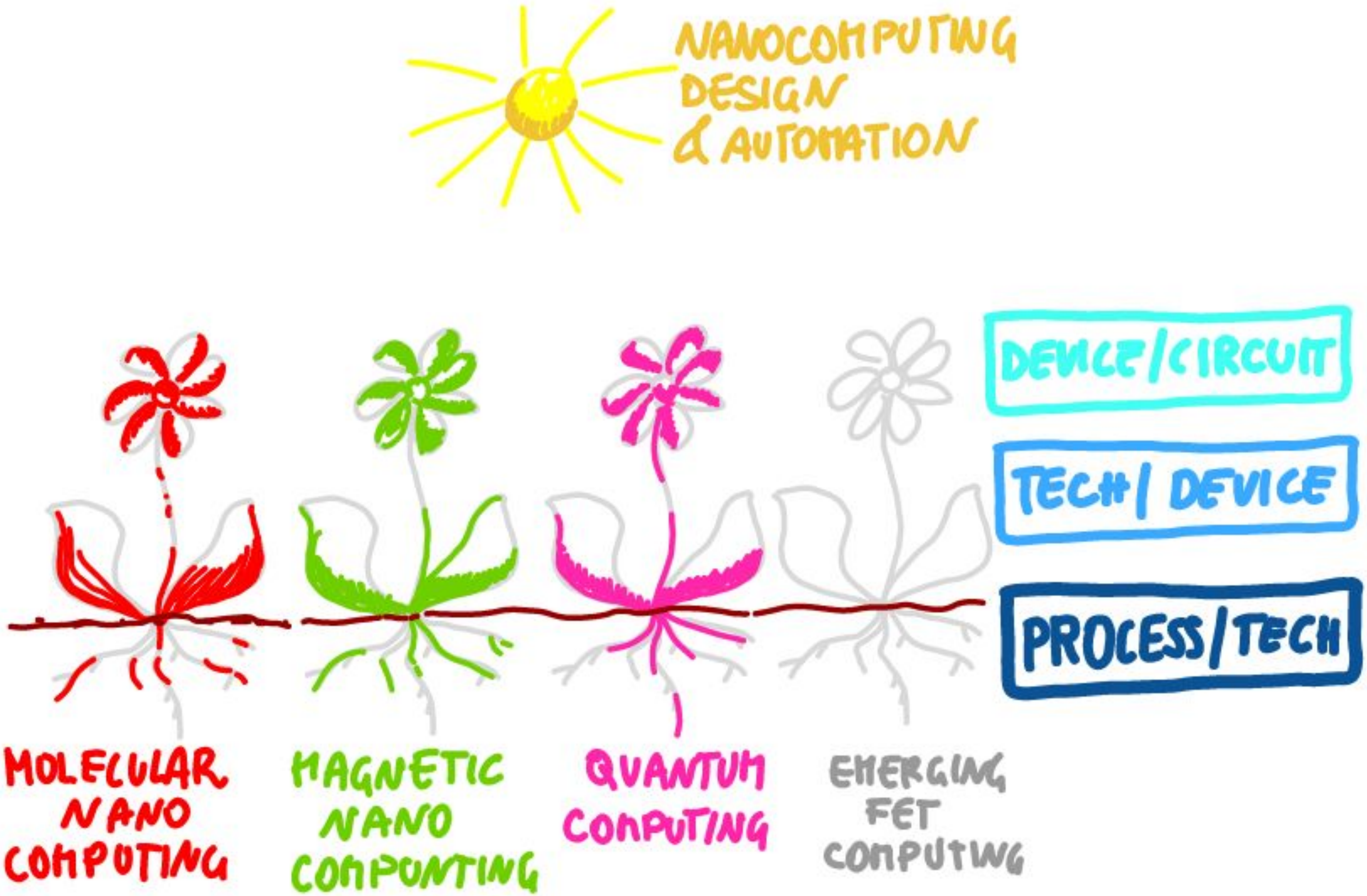
POLITECNICO
DI TORINO

VLSI LAB
NANOCOMPUTING

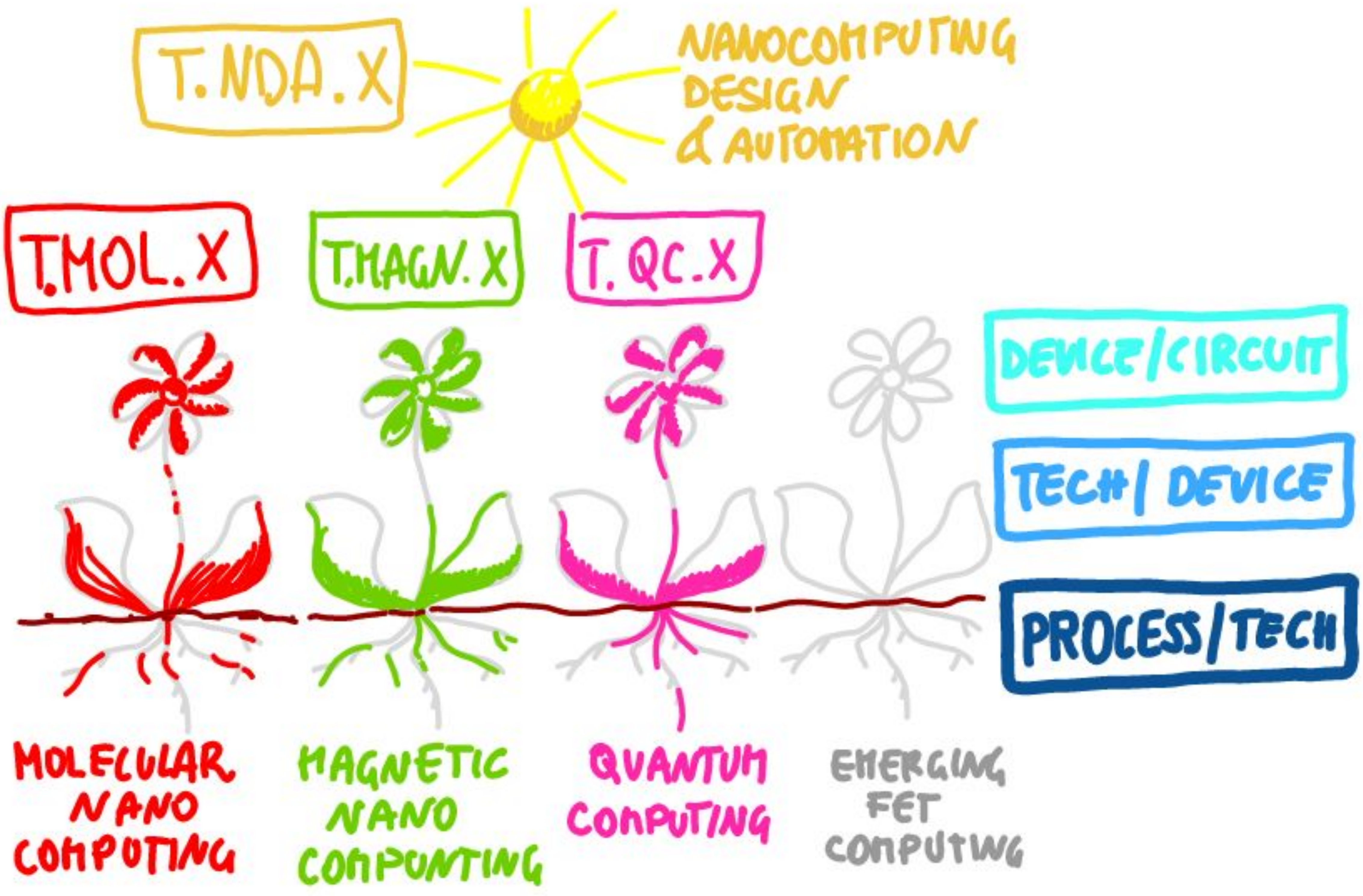
The NANOCOMPUTING approaches



3 colors for 3 approaches



The THESES names & numbers



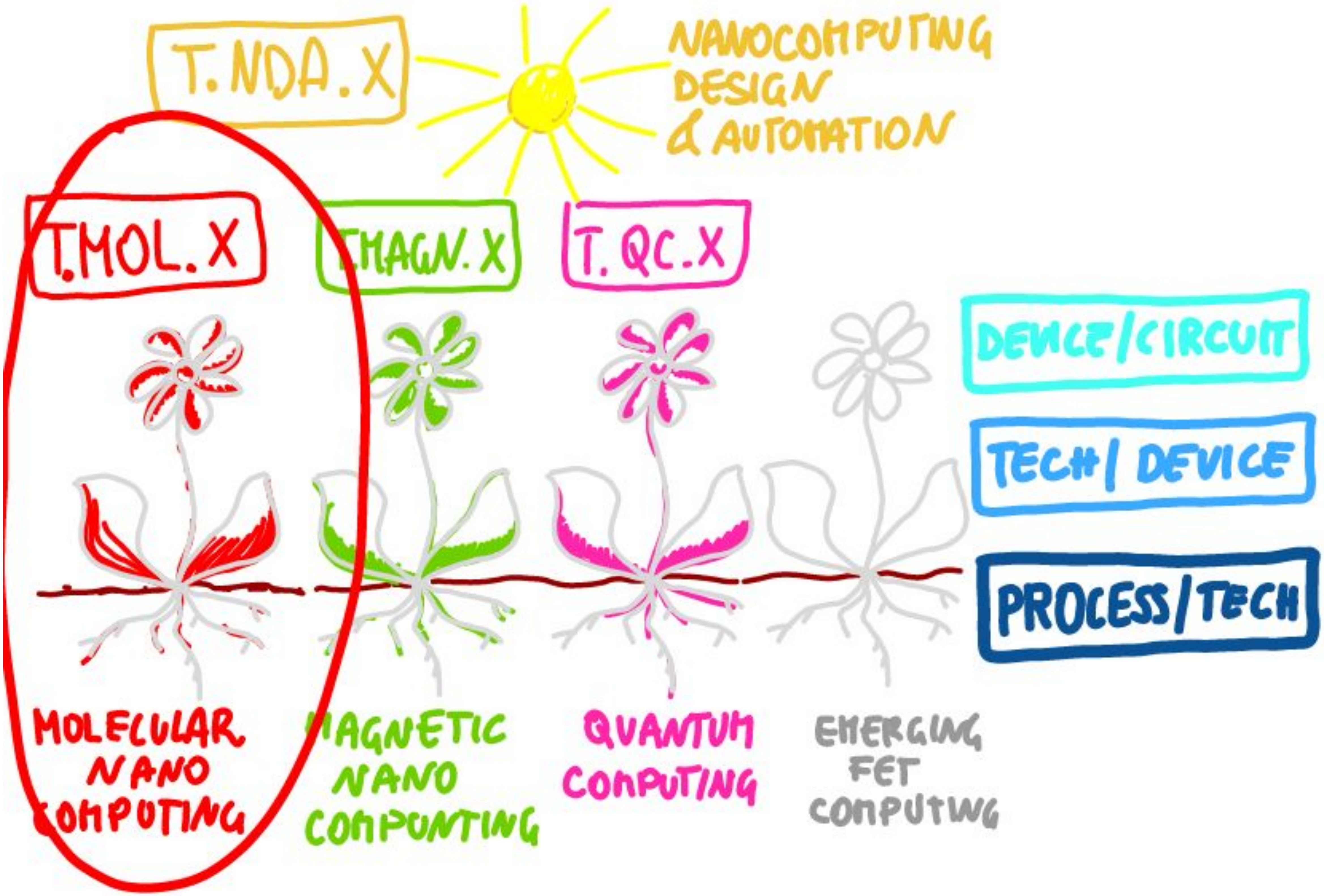
POLITECNICO DI TORINO

NANOCOMPUTING

Let’s explore the garden

POLITECNICO
DI TORINO

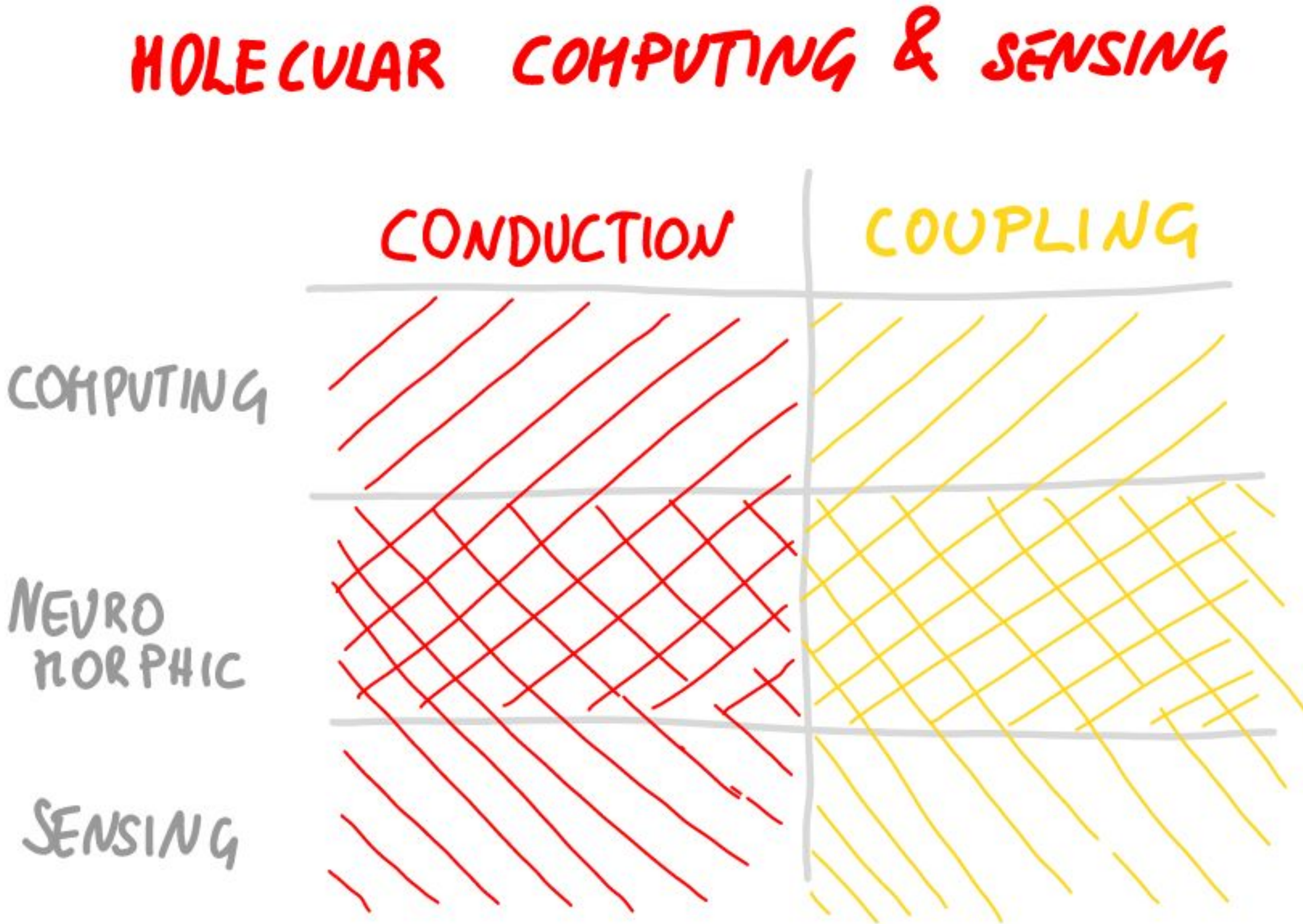
NANOCOMPUTING

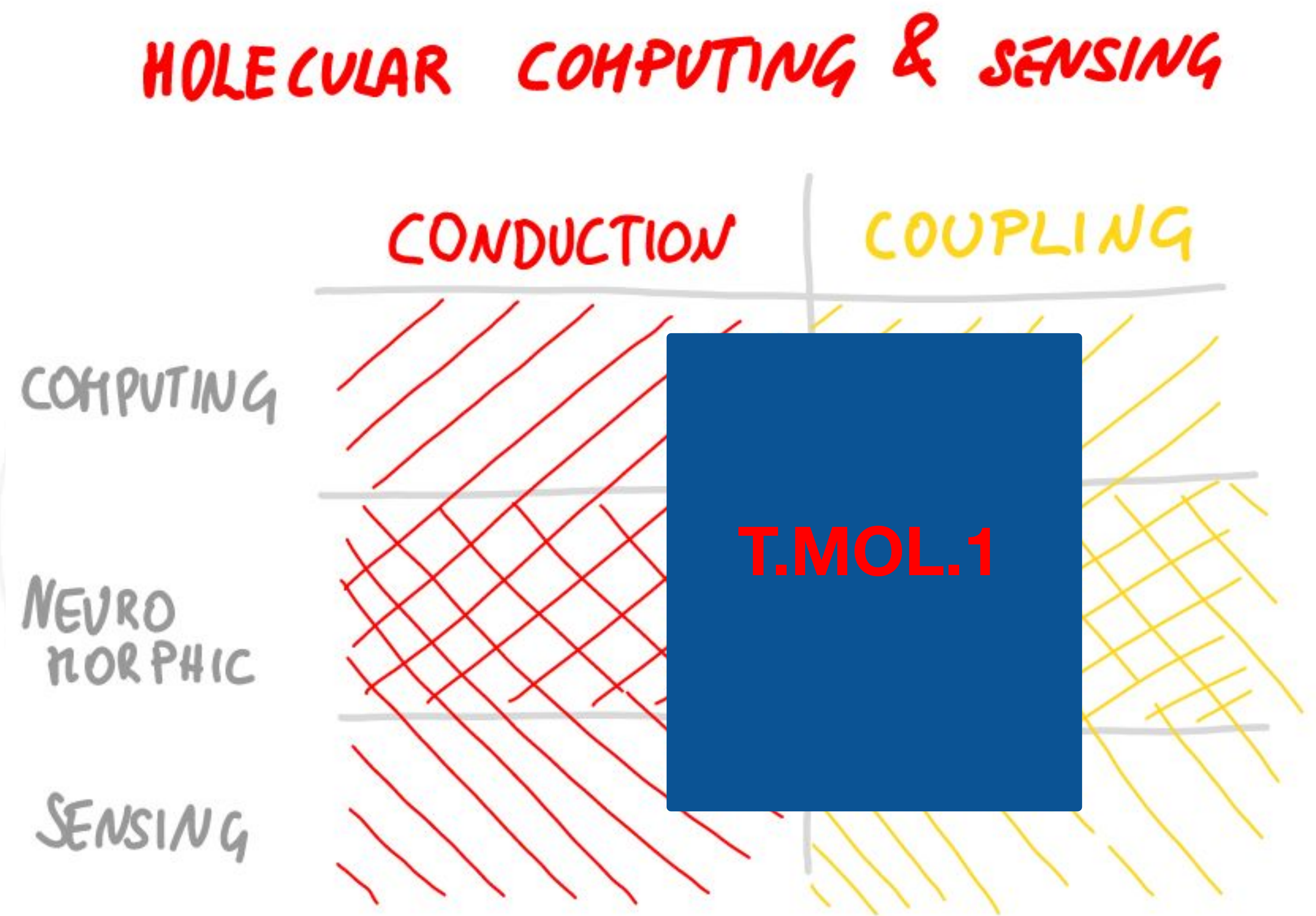


POLITECNICO DI TORINO

VLSI LAB NANOCOMPUTING

An inner MAP: technologies & applications





POLITECNICO DI TORINO

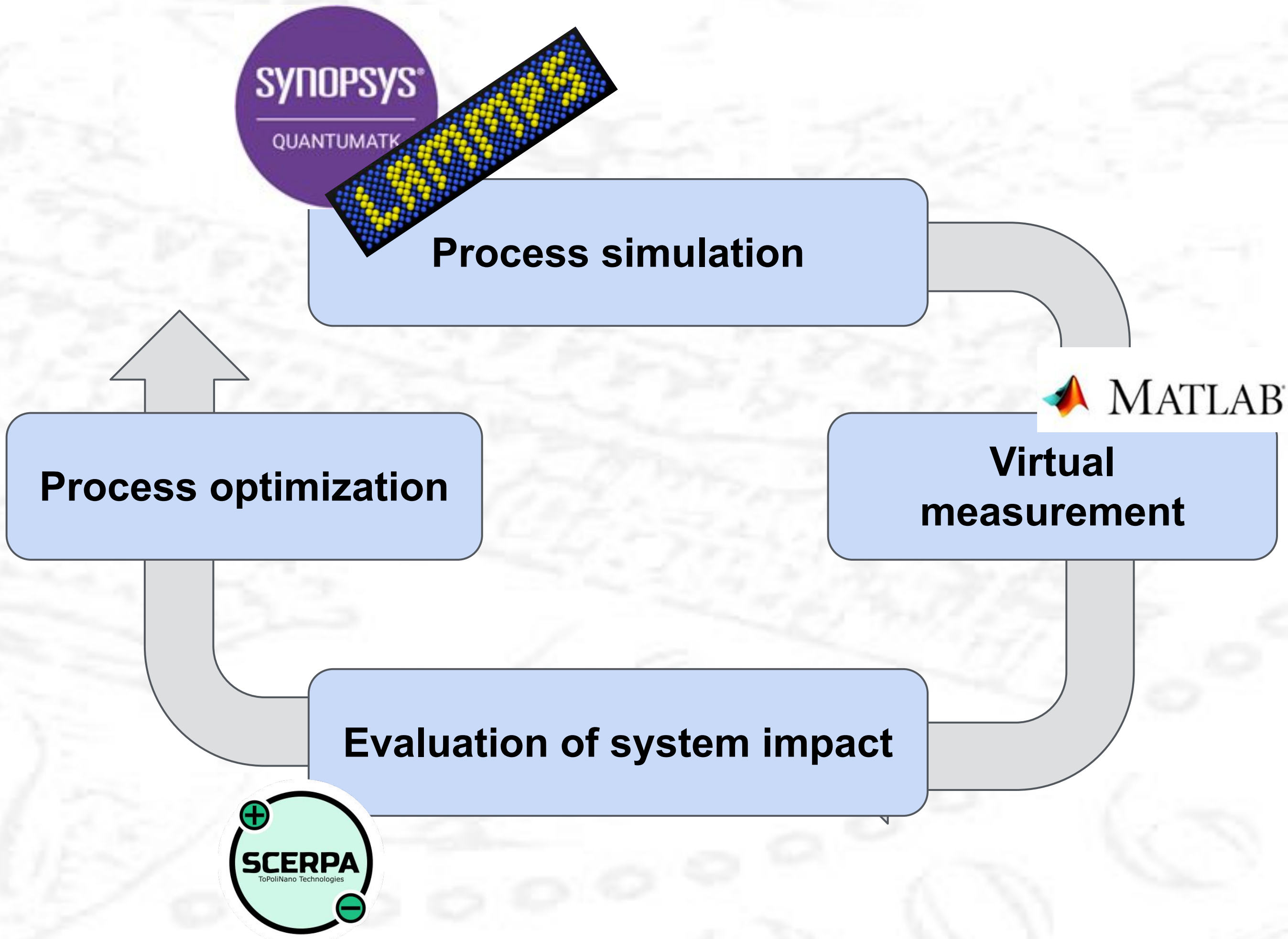
NANOCOMPUTING

T.MOL.1 Simulation of nano-fabrication processes (1/2)

Object: Simulate with Molecular Dynamics technological processes

Molecular devices are so small that the process variations and lattice geometries play a relevant role in the quality of the device.

Simulation of nanofabrication enable linking the technological parameters with the system-level perspective with very high precision, providing feedback to technologists and to designers.



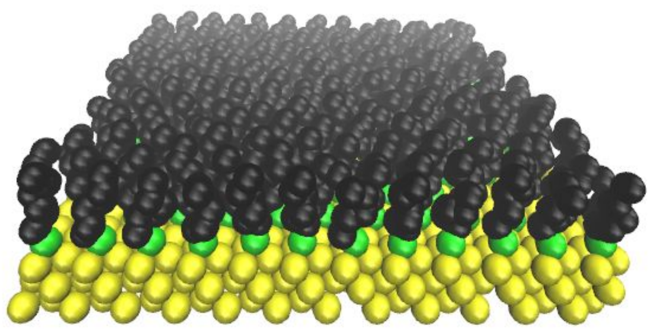
POLITECNICO DI TORINO

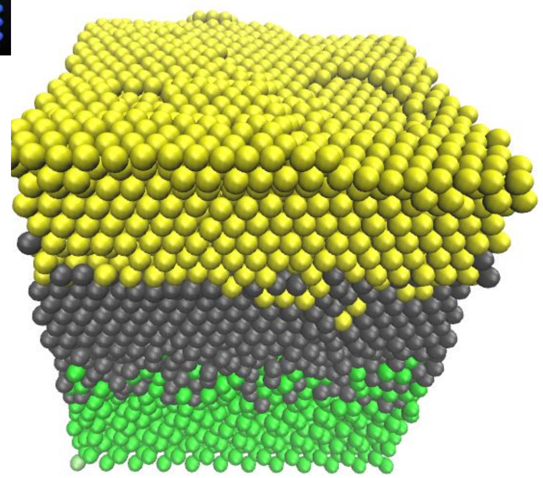
NANOCOMPUTING

T.MOL.1 Simulation of nano-fabrication processes (2/2)

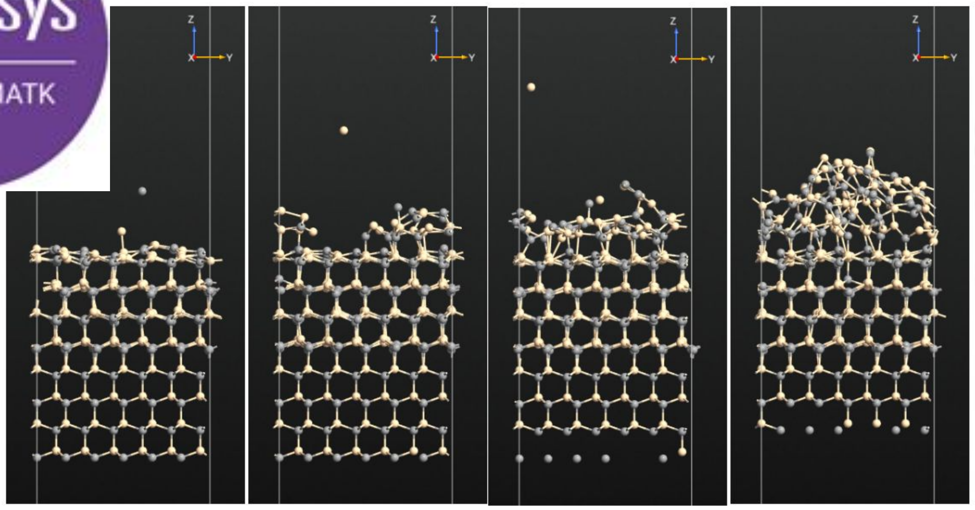
Object: Simulate with Molecular Dynamics technological processes

- Self-Assembled Monolayers
- Passivation and Nano-Lithography
- Fabrication of patterned devices
- Atomic Layer Deposition
- ...

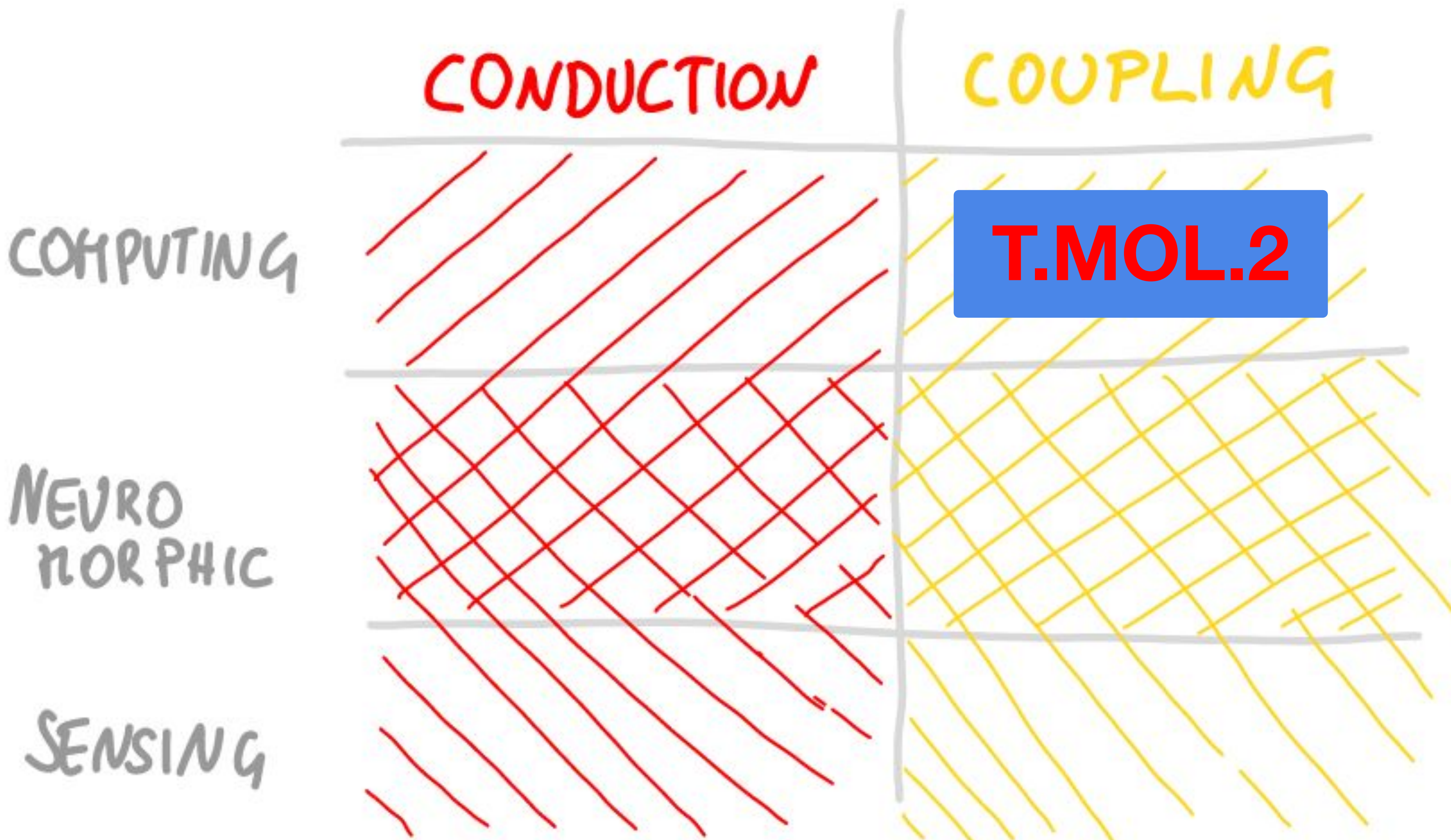




Compare the simulated results with experiments and verify models.
Explore the impact at higher level.



MOLECULAR COMPUTING & SENSING



POLITECNICO DI TORINO

VLSI LAB NANOCOMPUTING

T.MOL.2 Readout systems for MolFCN (1/2)

Object: Study new methods to sense the charge of a molecule

- Perform a literature analysis of the molecular charge sensing problem, identifying the techniques already documented in literature
- Study the effects of light on molecules with the aim of finding a way to sense the charge, investigate also alternative ways of doing it.
- Design and simulate a charge sensor exploiting one chosen technique (already present in literature or novel)

T.MOL.2 Readout systems for MolFCN (2/2)

Object: Study new methods to sense the charge of a molecule

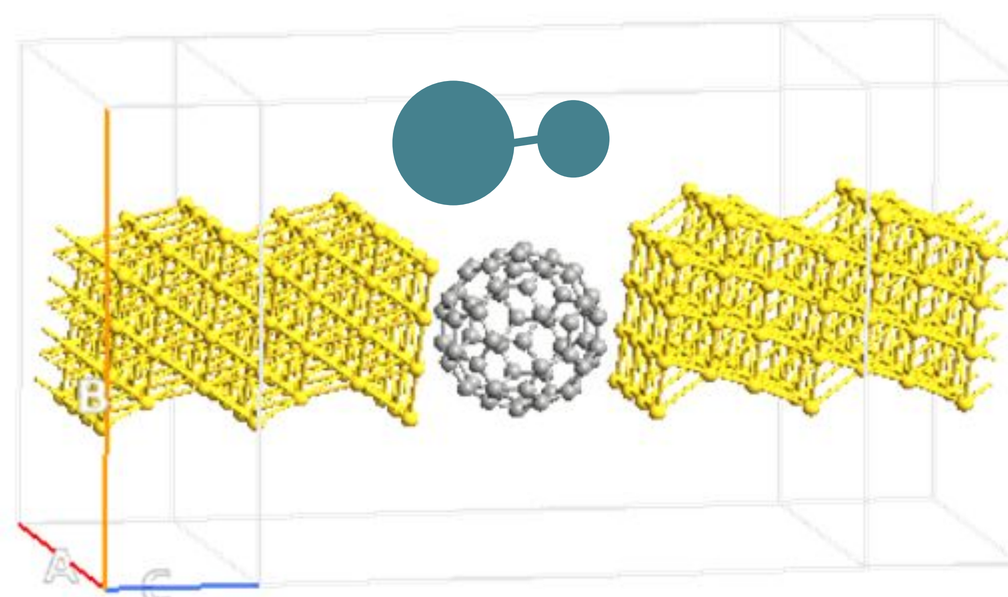
- Extraction of significant figures of merit for the characterization of the readout system performance and robustness
- Study the possible integration of the sensor in electronic circuits to create a CMOS/MolFCN interface
- Study the influence between the measurement system and the molecule under measurement

AB INITIO SIMULATORS

ORCA

synopsys QUANTUMATK

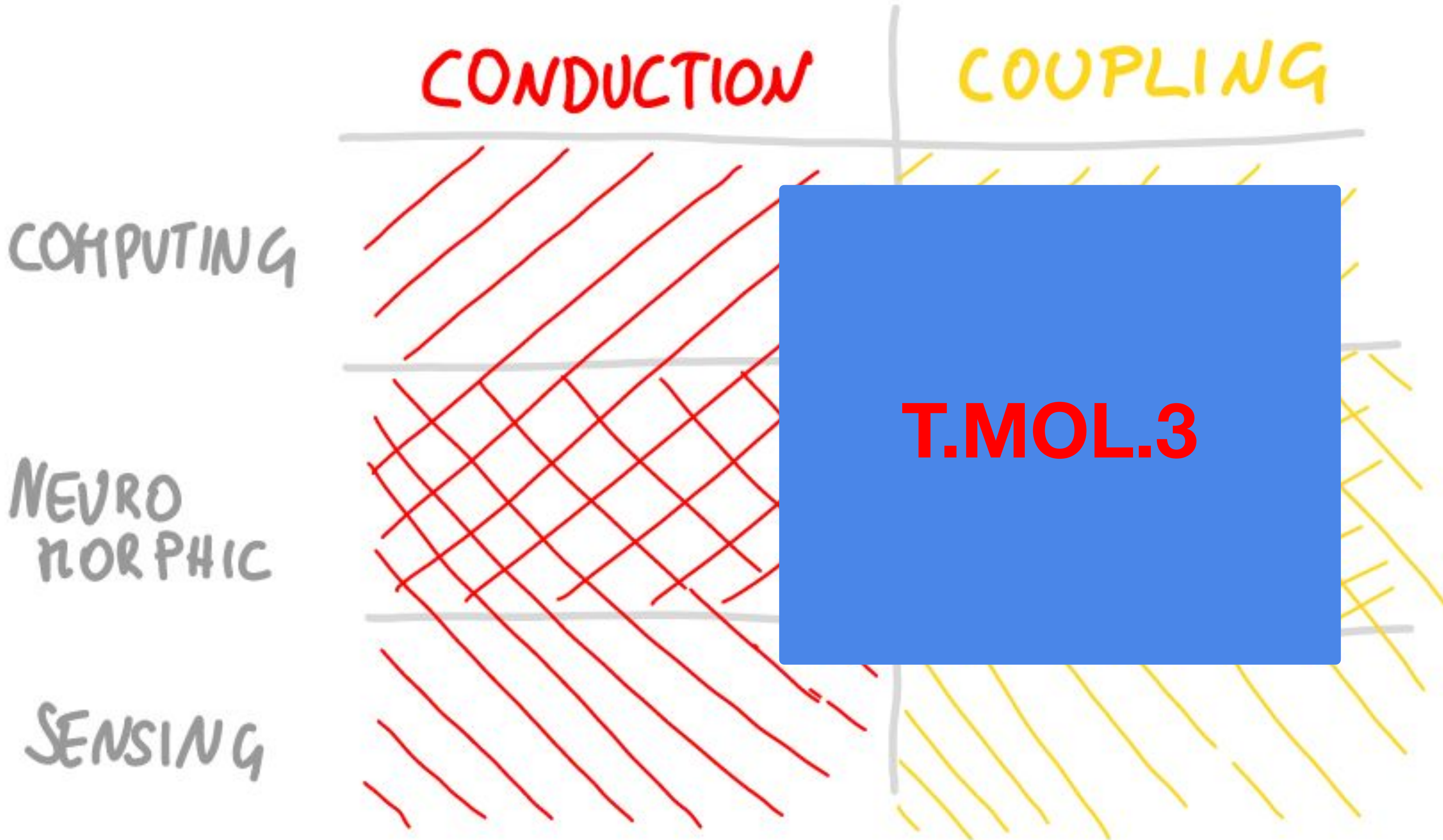
MolFET-based charge sensor



POLITECNICO DI TORINO

VLSI LAB NANOCOMPUTING

MOLECULAR COMPUTING & SENSING



POLITECNICO DI TORINO

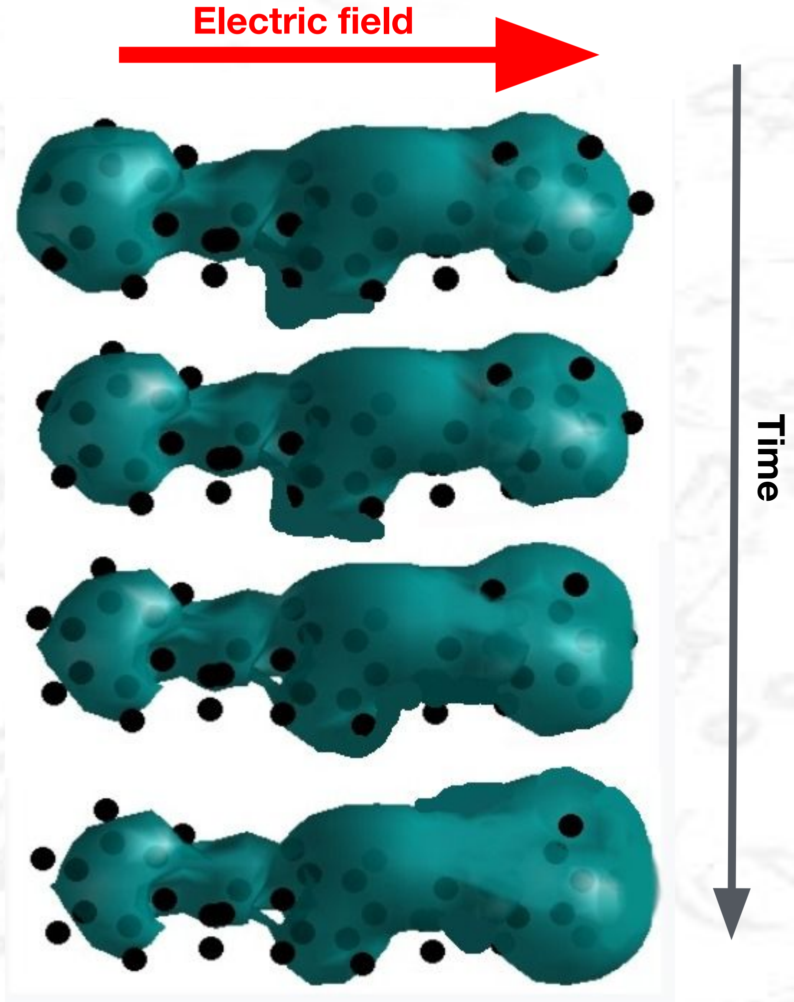
VLSI LAB NANOCOMPUTING

T.MOL.3 Study of quantum chemistry calculation for time-dependent molecular properties (1/2)

Object: Study of Time-Dependent Ab initio based techniques

In molecular electronics, the dynamic of molecules play a relevant role in the device working principle. Analysis of dynamic molecular properties are as essential as novel in the field of molecular electronics.

- Study of ab initio techniques and tools used to analyse the time-dependent properties of molecules (RT-TDDFT, AIMD, Ehrenfest MD, CPMD)
- Analysis of simple time-dependent properties
- Study of time-dependent electrostatic properties (Electrostatic Potential, dipole moment, molecular charge distribution)



Charge density of a molecule under the effect of electric fields

POLITECNICO DI TORINO

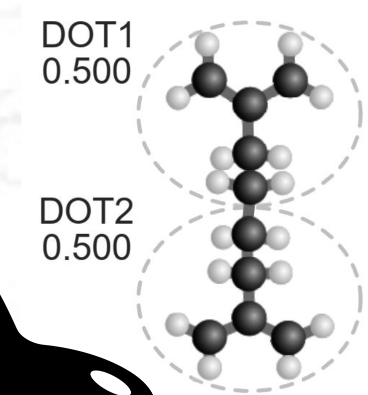
VLSI LAB NANOCOMPUTING

T.MOL.3 Study of quantum chemistry calculation for time-dependent molecular properties (2/2)

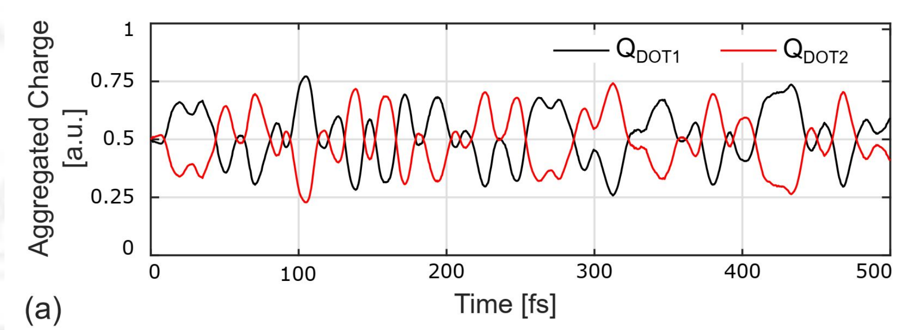
Object: Study of Time-Dependent Ab initio based techniques

A possible application: **Molecular FCN**

- Study the switching of molecules for MolFCN applications. Study the effect of molecular vibrations.
- Study the propagation of the MolFCN information considering time-dependent parameters. Eventually integrating a dynamic model into the SCERPA algorithm.
- Study the propagation of the information in the presence of an adiabatic clock field and in a clock-wall scenario.



ORCA

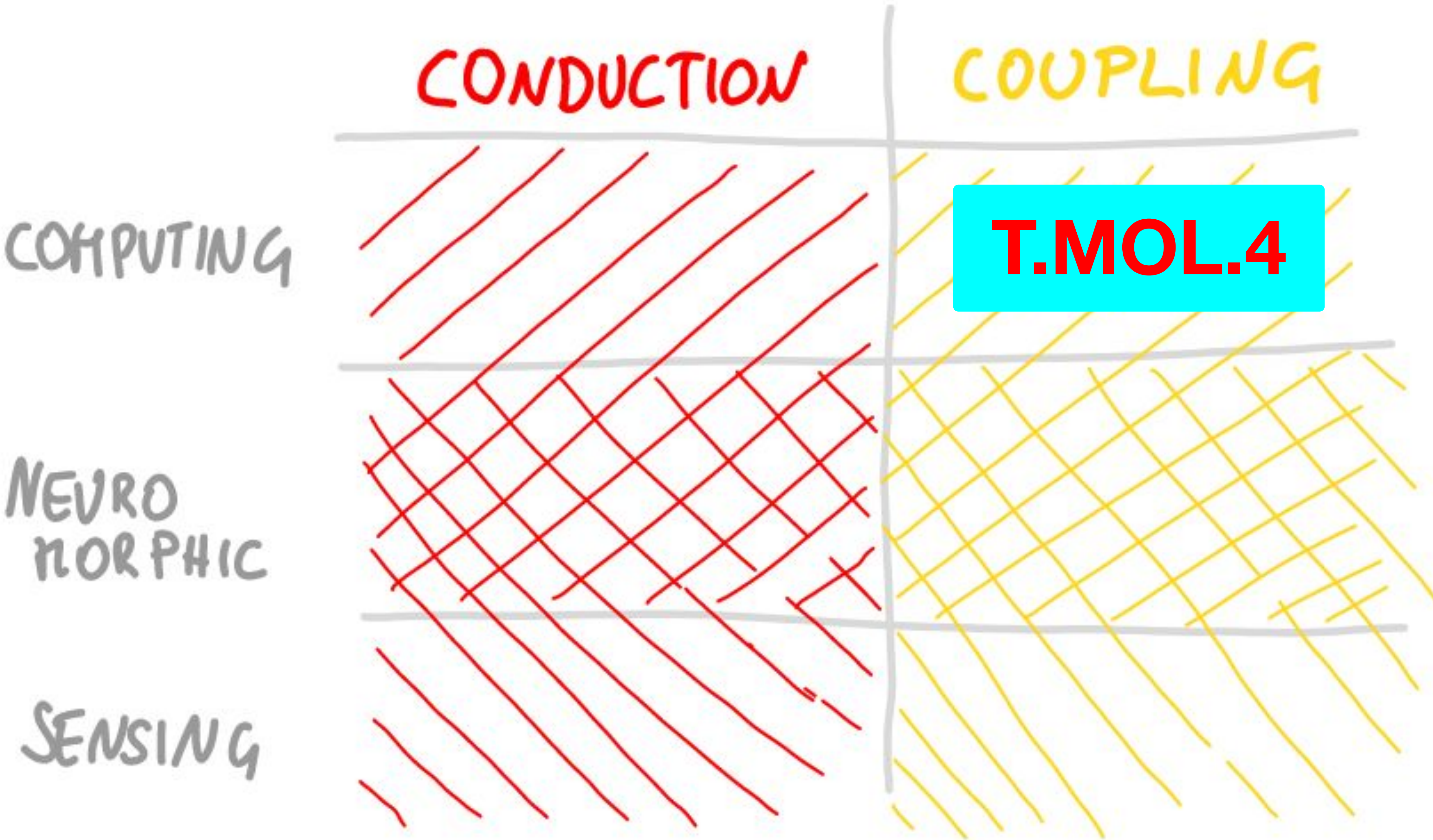


Time-evolution of the 1,4 diallyl-butane Aggregated Charge (Molecular Dynamics)

POLITECNICO DI TORINO

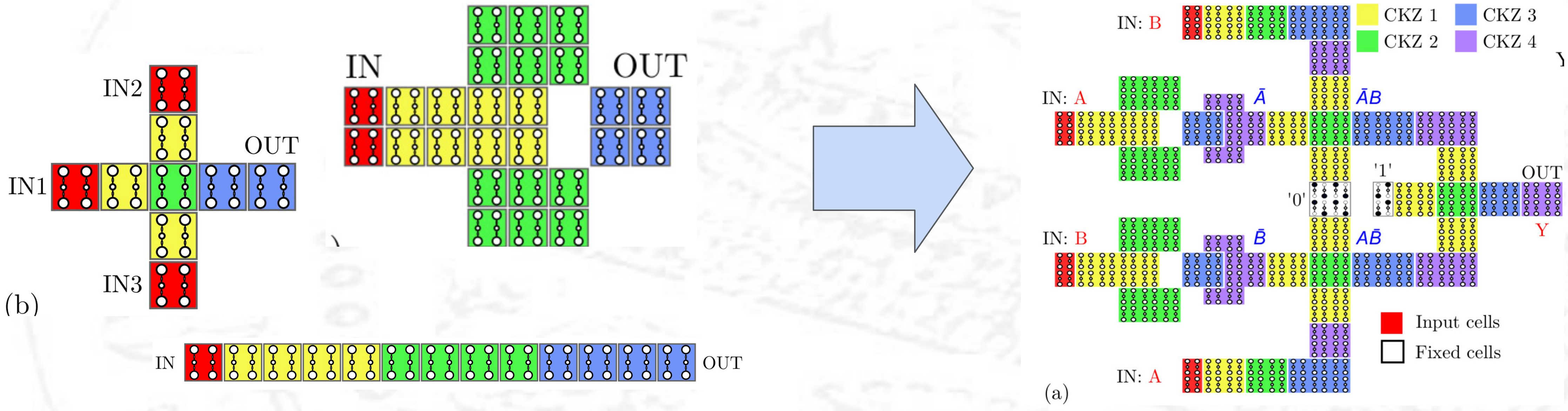
VLSI LAB NANOCOMPUTING

MOLECULAR COMPUTING & SENSING



T.MOL.4 Design of MOLFCN: Abstraction Level Increase (1/2)

Object: Derive a methodology to create a library of molecular devices

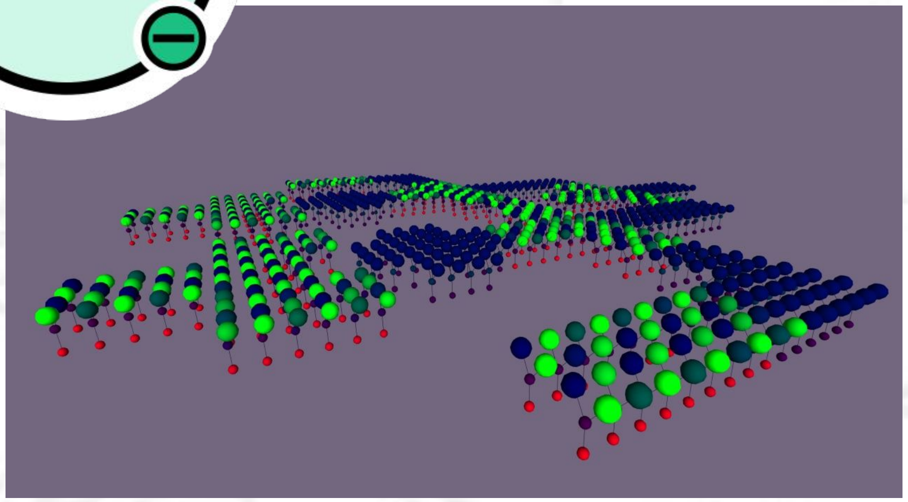


- Design basic logic devices using the SCERPA algorithm
- Model the device in terms of input/output voltage
- Verify the Safe-Operating area of the model by evaluating possible crosstalk with other devices

T.MOL.4 Design of MOLFCN: Abstraction Level Increase (2/2)

Object: Derive a methodology to create a library of molecular devices

- Connect devices and model possible inter-device interactions
- Design and verify complex circuits
- Insert the model-based device within the SCERPA simulation environment



Future advanced works:

- Exploit FEM (COMSOL/ELMER) Model of robust devices with technological parameters. Process variations and electrical characteristics (power, delay of electrodes).
- Auto-routing

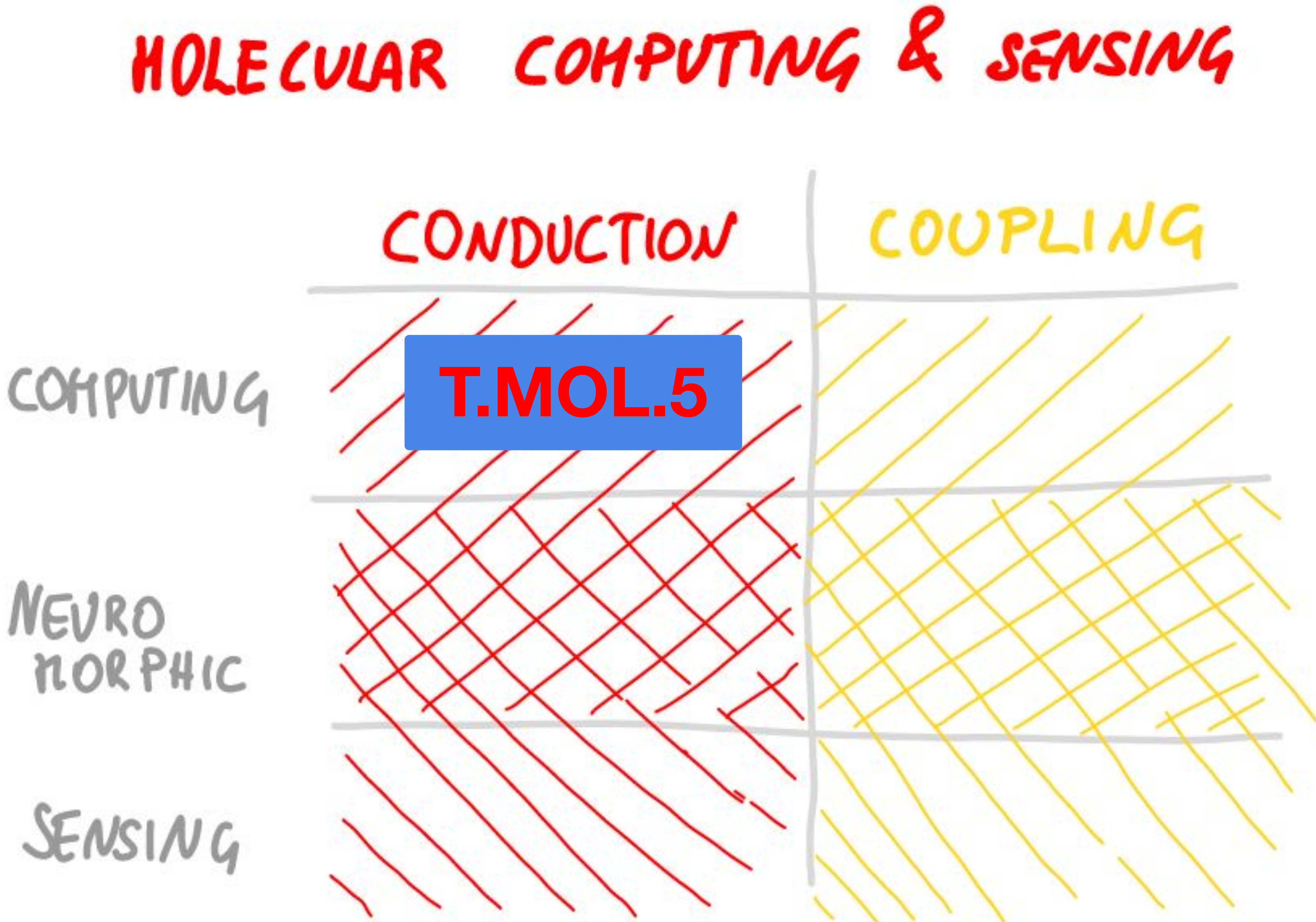
SCERPA
ToPoliNano Technologies

COMSOL

Elmer

POLITECNICO DI TORINO

VLSI LAB NANOCOMPUTING



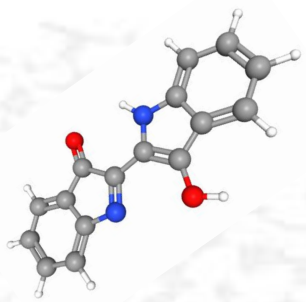
POLITECNICO
DI TORINO

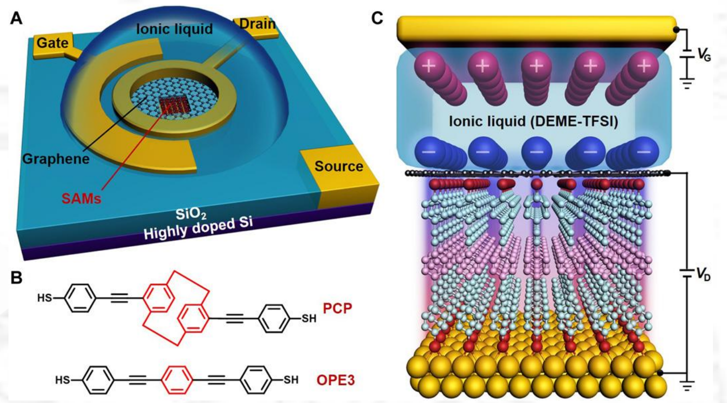
VLSI LAB
NANOCOMPUTING

T.MOL.5 Technological study of MolFET (1/2)

Object: Perform a systematic physical and device level study of the Molecular FET

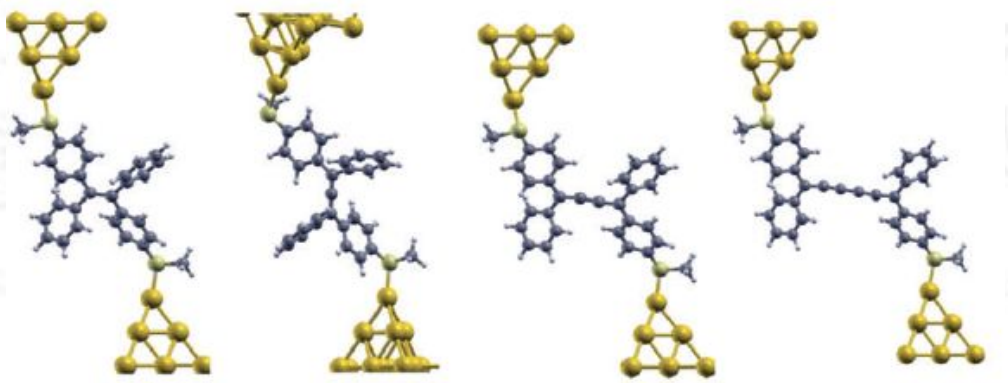
- Physical characterization of new molecules suitable for conduction (e.g. biodegradable molecules)





- Study of the dependance of channel length on conduction (ohmic, anti-ohmic trends)

- Study of the effects of the anchoring groups



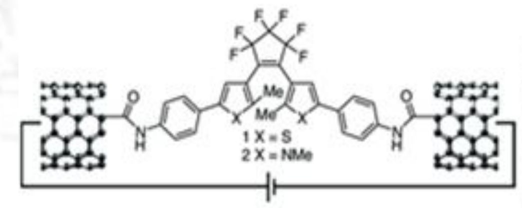
POLITECNICO DI TORINO

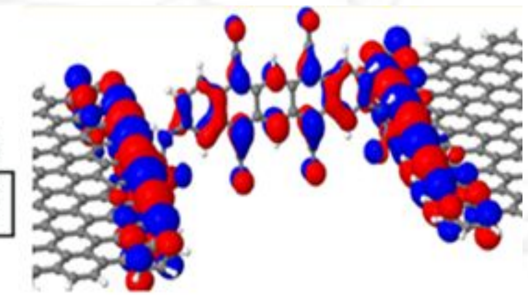
VLSI LAB NANOCOMPUTING

T.MOL.5 Technological study of MolFET (2/2)

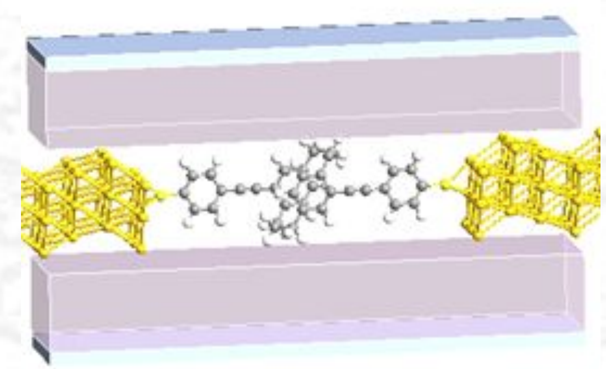
Object: Perform a systematic physical and device level study of the Molecular FET

- Study of the effects of less conventional materials for electrodes (Pt, Graphene, cupped-graphene, …)

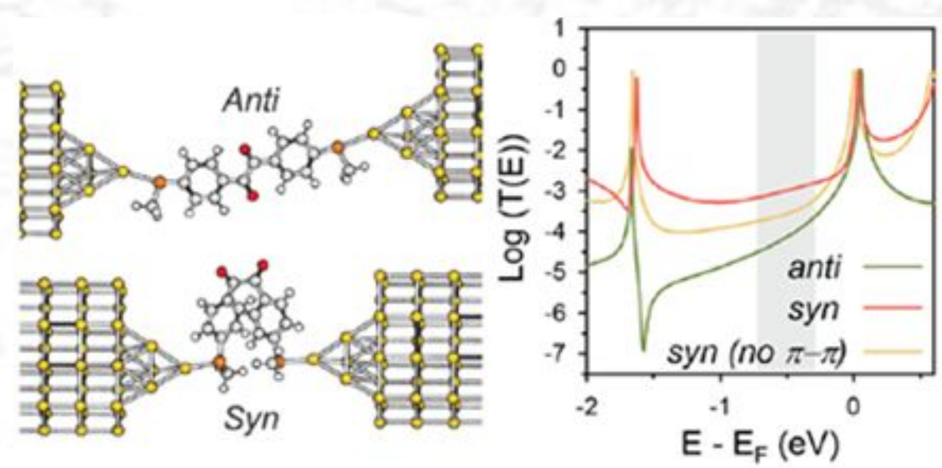




- Study of the dependance of gate/backgate oxide material (HfO2, ZrO2, …) and geometries on current modulation



- Evaluation of process variations (e.g. torsion, bending, folding of molecule, ...)



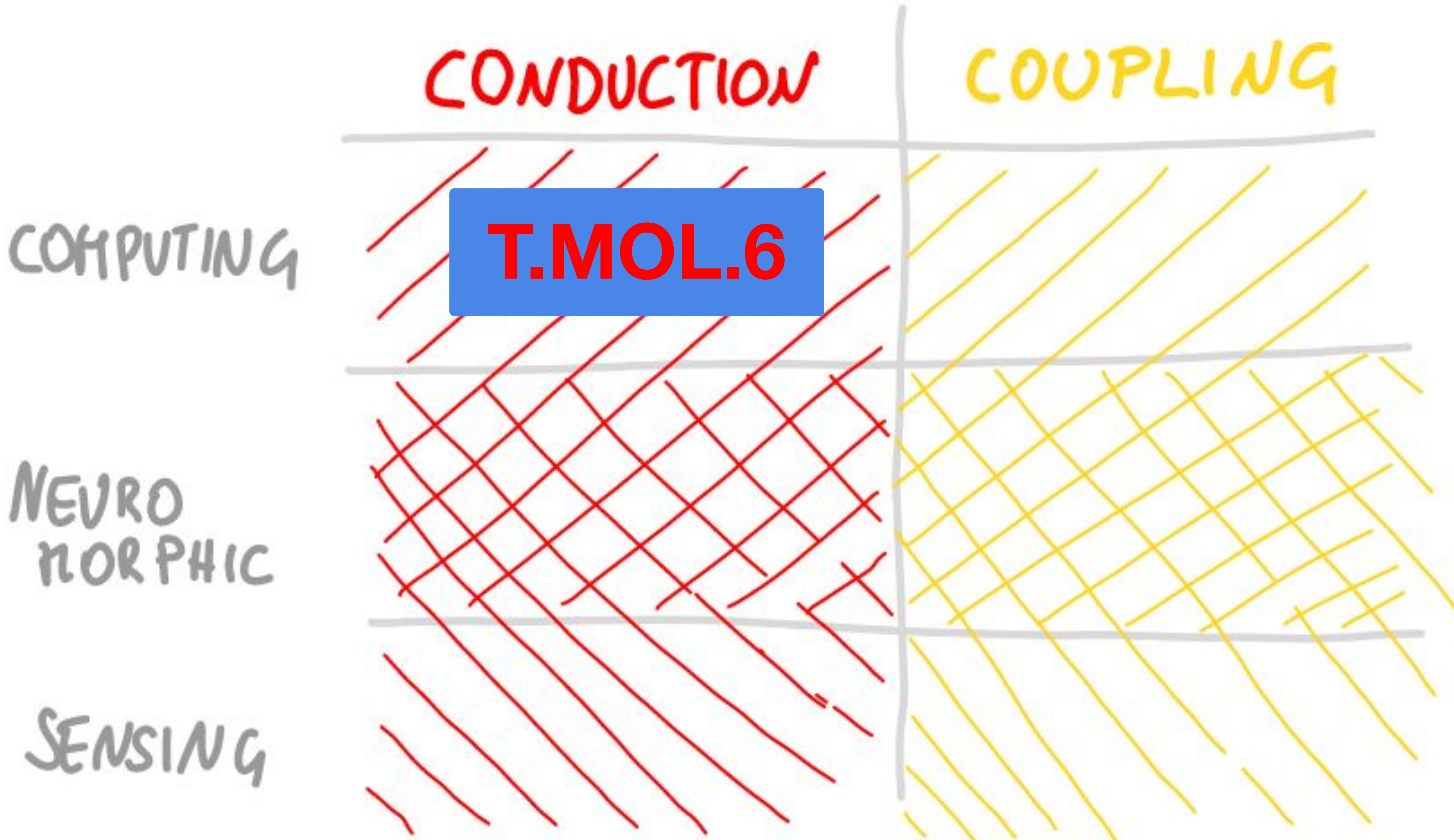
POLITECNICO DI TORINO

SYNOPSYS QUANTUMATK

MATLAB

VLSI LAB NANOCOMPUTING

MOLECULAR COMPUTING & SENSING

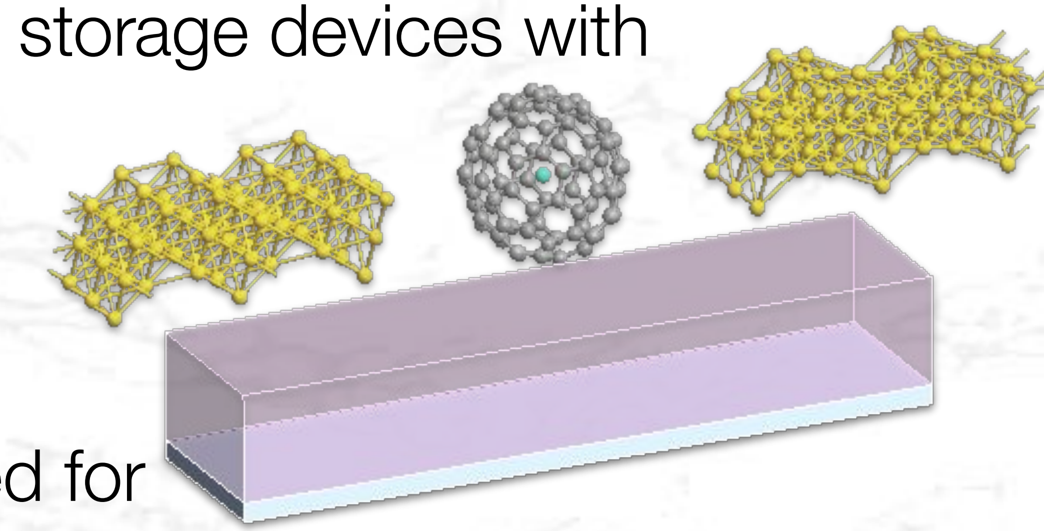


POLITECNICO
DI TORINO

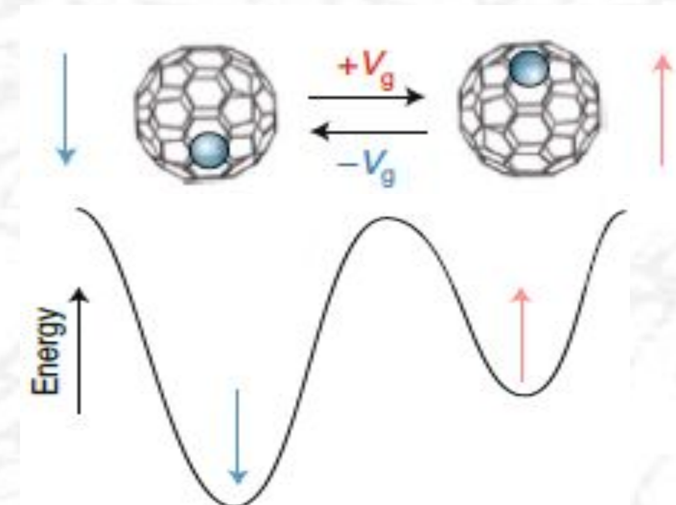
VLSI LAB
NANOCOMPUTING

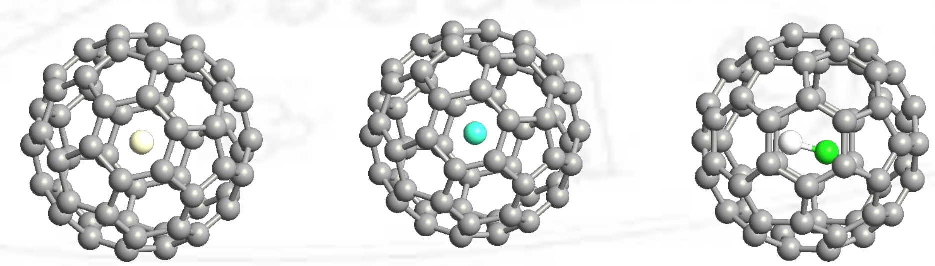
T.MOL.6 Electret: In-Memory Molecular Computing (1/2)

Object: Study and characterization of molecular storage devices with computing abilities.



- State-of-art analysis of electret devices
- Study of ab-initio/semiempirical techniques used for static and transient physical analysis of molecules (DFT/EHT + NEG, MD models)
- Physical study with atomistic simulations of trapped atoms within molecular cages, …)
- Study the influence of different trapped atoms/diatomic molecules (Gd, Ce, ScCl, CaO,...)



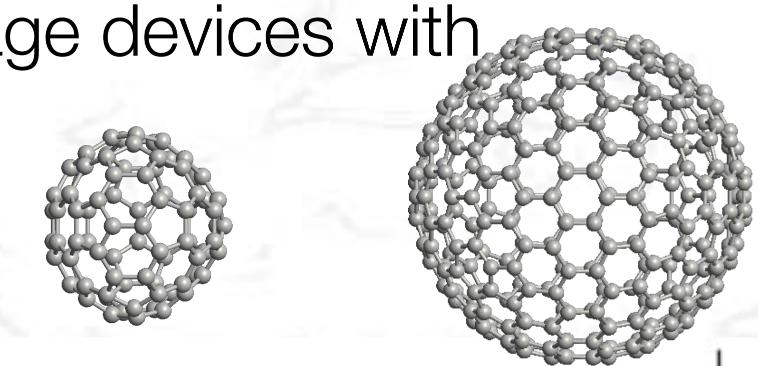


POLITECNICO DI TORINO

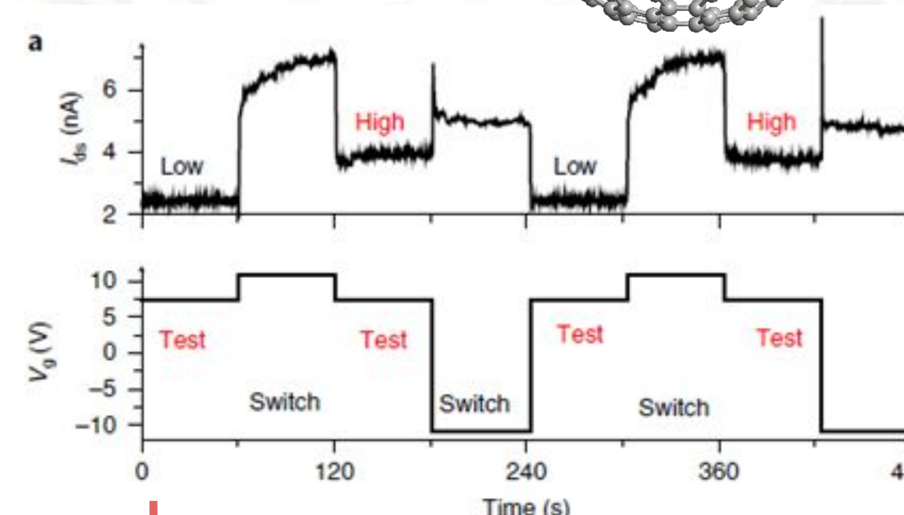
VLSI LAB NANOCOMPUTING

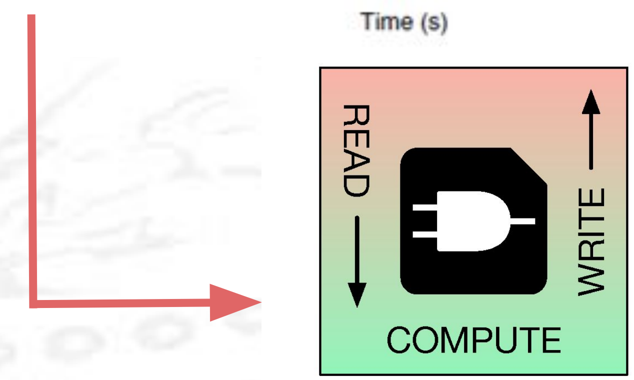
T.MOL.6 Electret: In-Memory Molecular Computing (2/2)

Object: Study and characterization of molecular storage devices with computing abilities.



- Study of the influence of different molecular cages (C60, C70, C82, …) and their geometry
- Characterization of the device by figures of merit extraction (write/read times, write/read currents, data retention time, ...)
- Circuital level simulations of the LiM cell and LiM array with EDA tools





Logic-in-Memory

Custom IC Design
Virtuoso
cadence

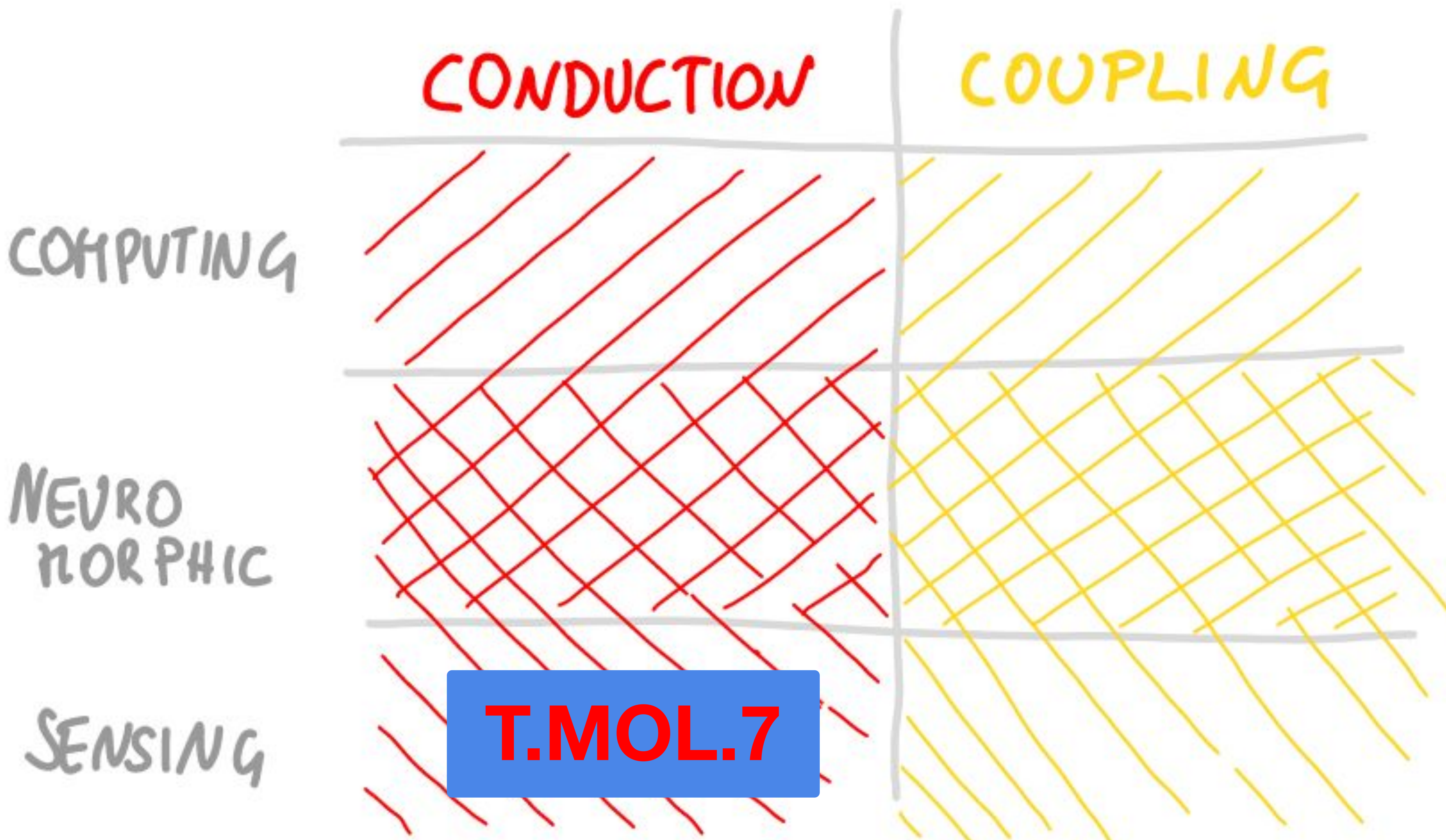
SYNOPSYS
QUANTUMATK

MATLAB

POLITECNICO
DI TORINO

VLSI LAB
NANOCOMPUTING

MOLECULAR COMPUTING & SENSING



POLITECNICO DI TORINO

NANOCOMPUTING

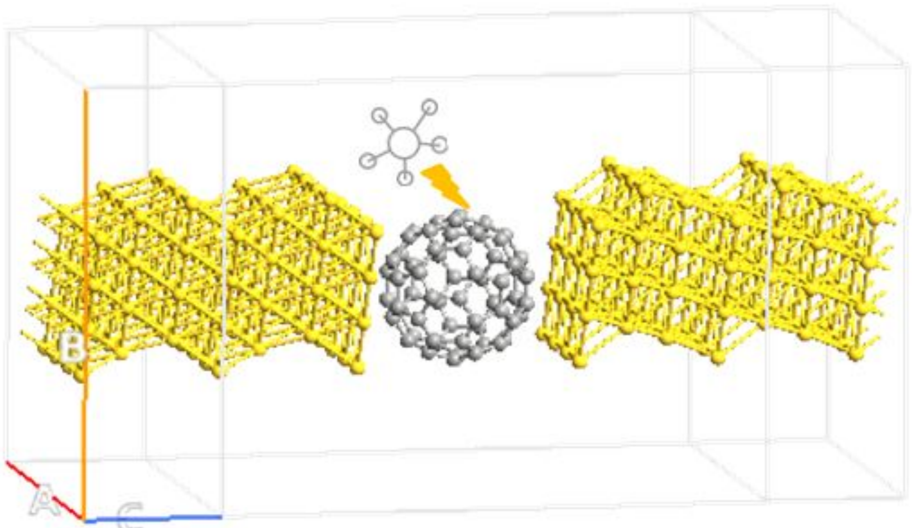
T.MOL.7 Molecular Sensor Analysis (1/2)

Object: Investigate the sensing capability of molecular devices

- Literature review on molecular electronic sensors
- Deep study of the physical-chemical model for gas detection and single molecule detection mechanisms
- Device level analyses: detection mechanism, target sensitivity, optimal channel choice, optimal contact material for sensing application, etc…

$$I = \frac{2q}{h}\int_{-\infty}^{+\infty} T(E)\,[\,f_1(E) - f_2(E)\,]\,dE$$

Full quantum mechanical treatment (NEGF)

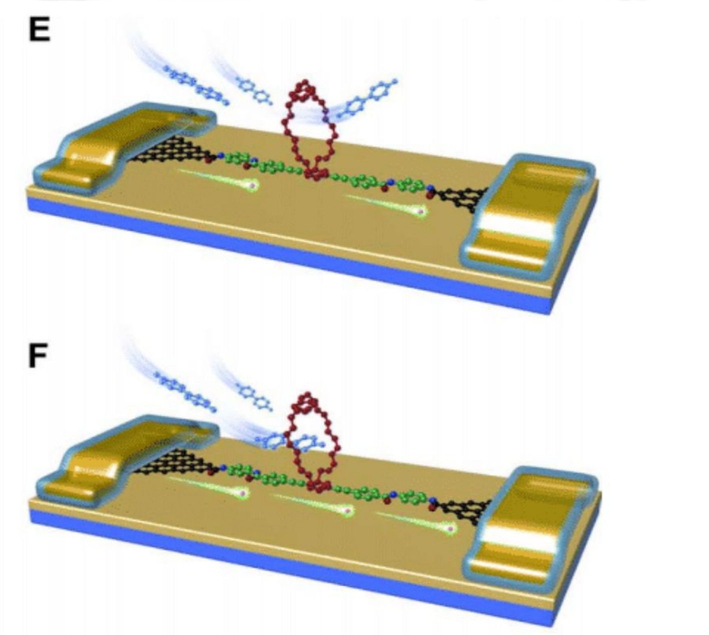


POLITECNICO DI TORINO

T.MOL.7 Molecular Sensor Analysis (2/2)

Object: Investigate the sensing capability of molecular devices

- Extraction of important device-level figures of merit and sensor characterization
- Usage of molecular dynamics analysis techniques to understand the target adsorption mechanism by the device molecular channel
- Study of the effects of the gate on the detection capability
- Equivalent circuit for the developed sensor



SYNOPSYS QUANTUMATK

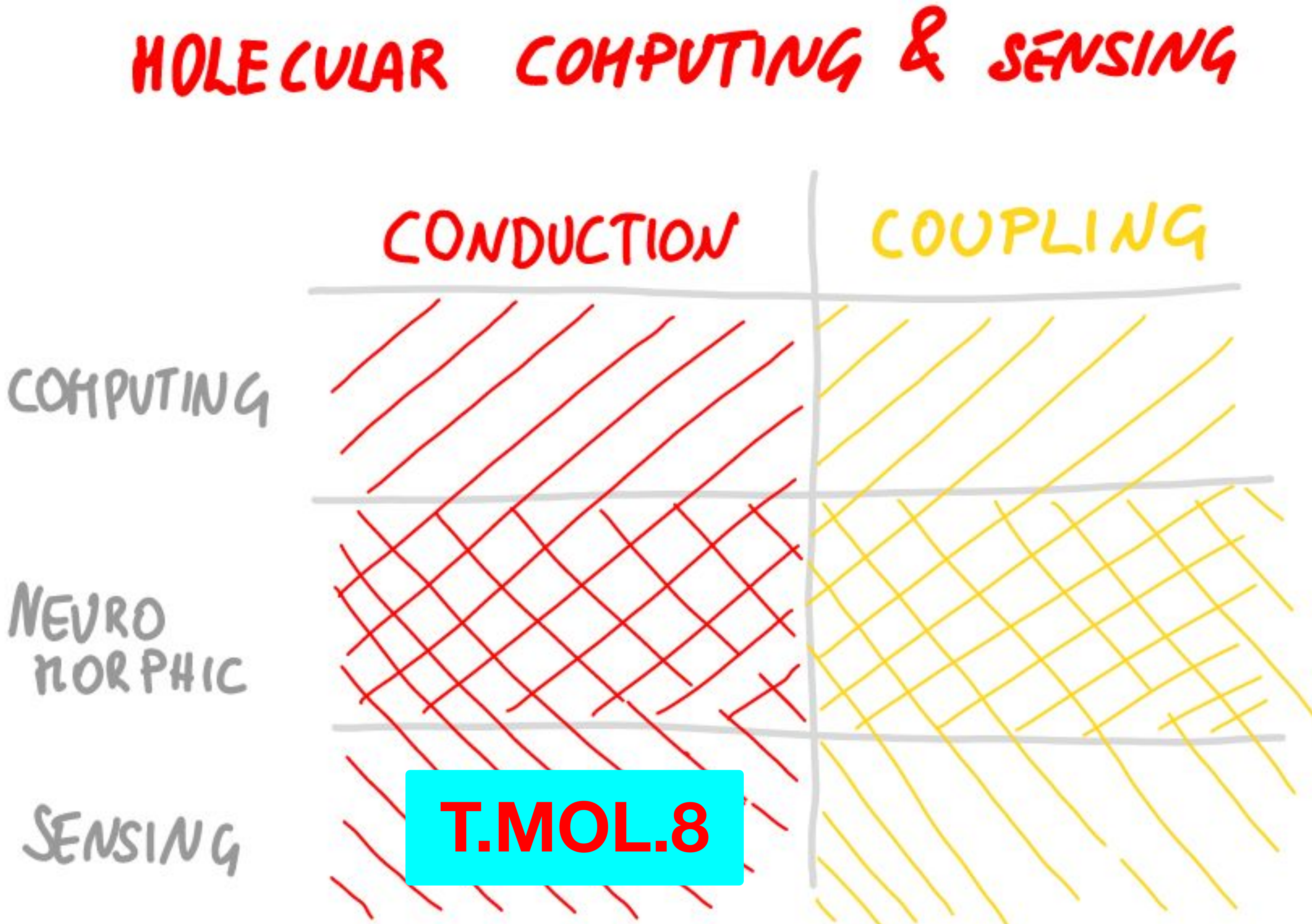
Custom IC Design Virtuoso cadence

MATLAB

LAMMPS

POLITECNICO DI TORINO

VLSI LAB NANOCOMPUTING



POLITECNICO DI TORINO

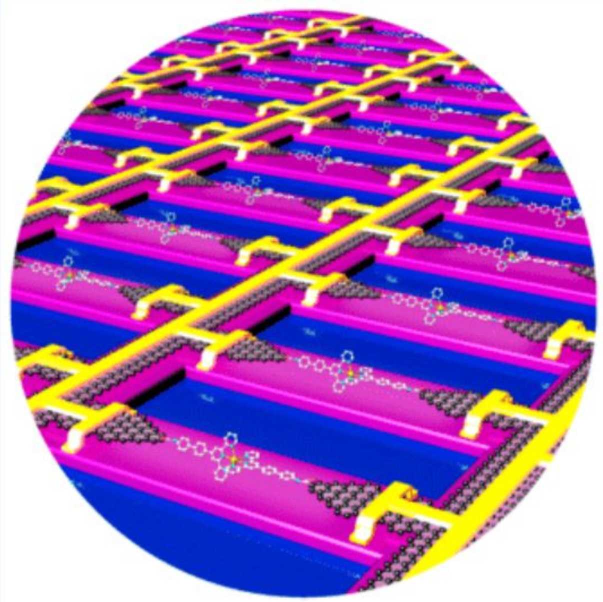
VLSI LAB NANOCOMPUTING

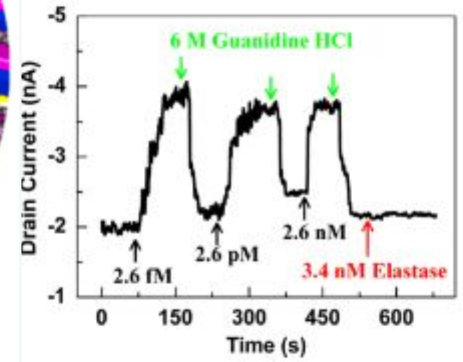
T.MOL.8 Molecular Sensor Systems (1/2)

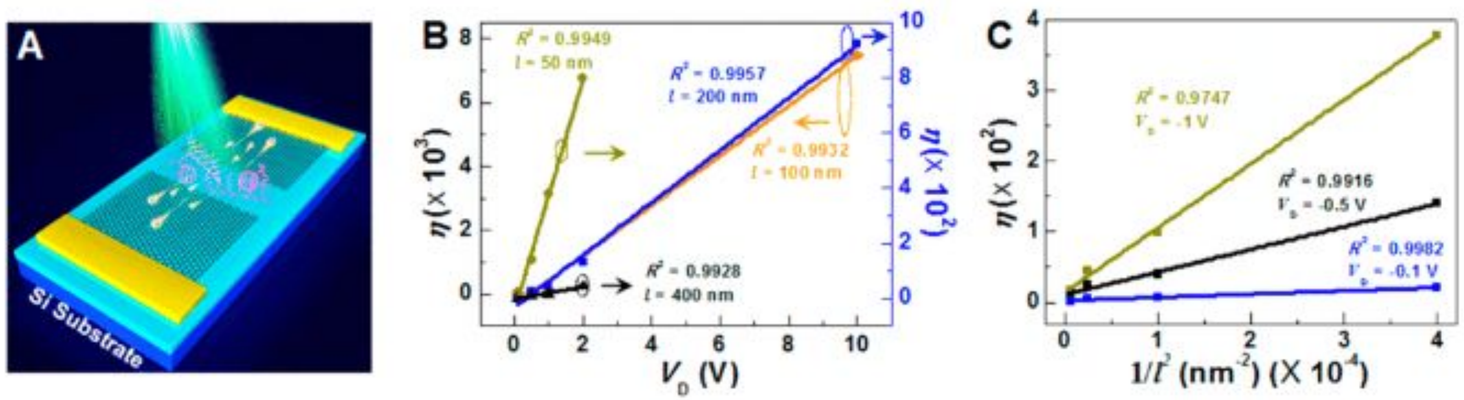
Object: Investigation of CMOS/innovative circuit architectures/topologies for molecular sensor applications

- Study of the basic principle of detection in molecular sensors and device-level meaningful parameters

- Literature review and study of conditioning circuits suitable for molecular sensors signal conditioning and processing







POLITECNICO
DI TORINO

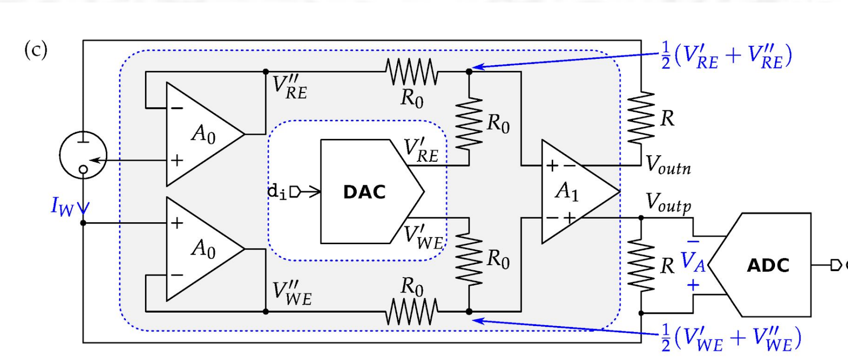
T.MOL.8 Molecular Sensor Systems (2/2)

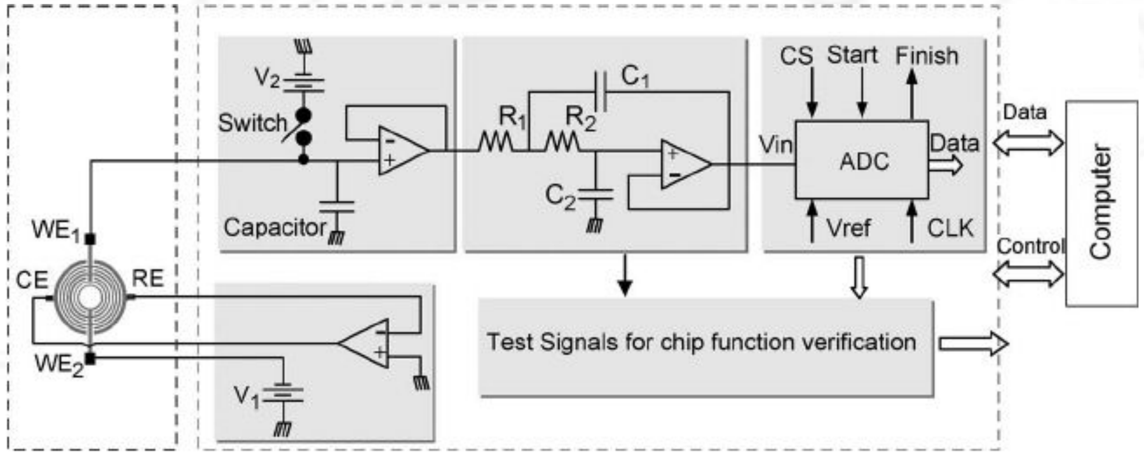
Object: Investigation of CMOS/innovative circuit architectures/topologies for molecular sensor applications

- Investigation of architectural and topological solutions for reliable target detection in such kind of sensors
- Design and verification (by means of simulations) of a suitable and reliable conditioning circuit for sensing applications (using Cadence Virtuoso), starting from an equivalent circuit-level model for molecular sensors

Custom IC Design Virtuoso cadence

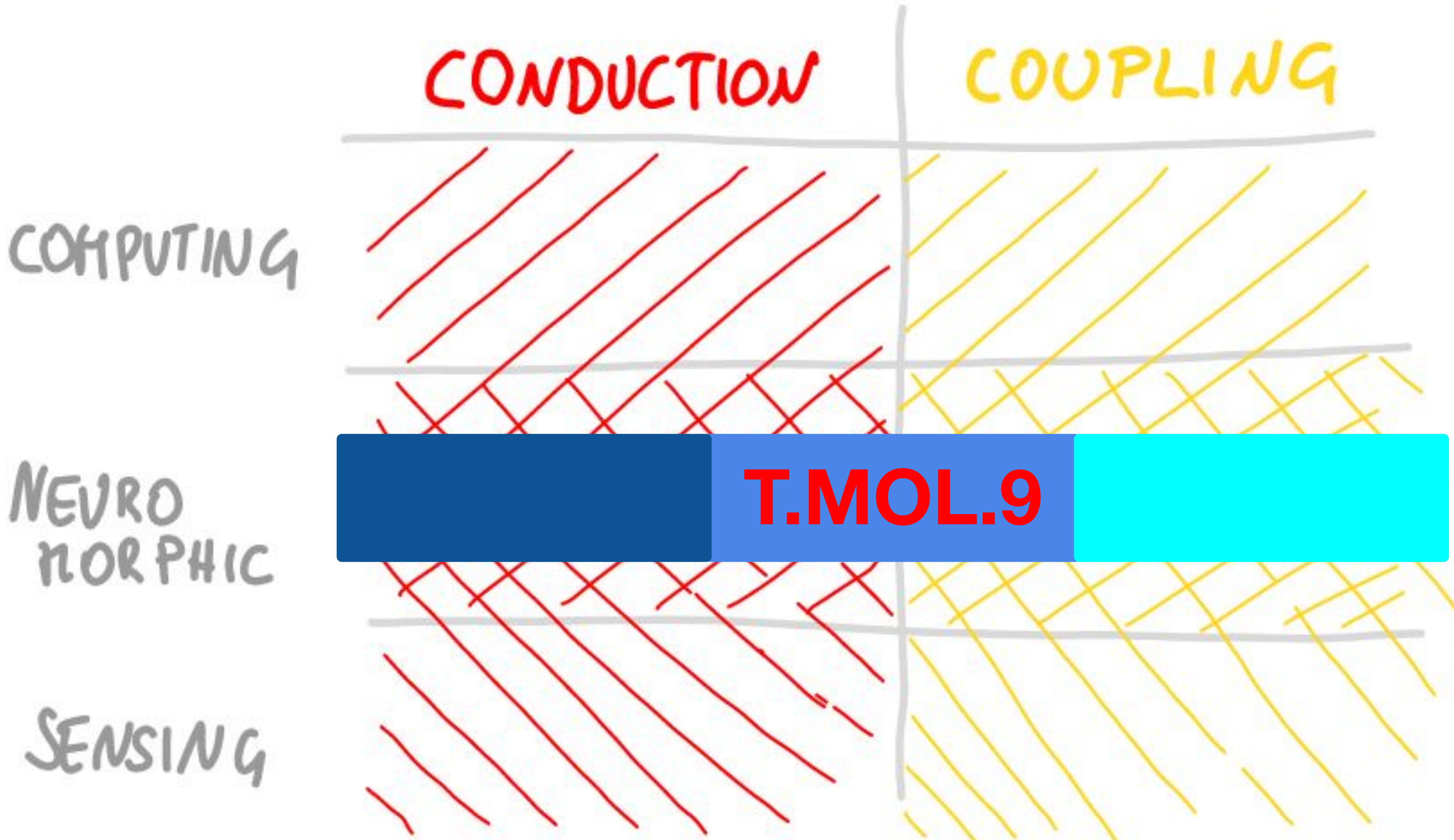
MATLAB





POLITECNICO DI TORINO

MOLECULAR COMPUTING & SENSING



T.MOL.9

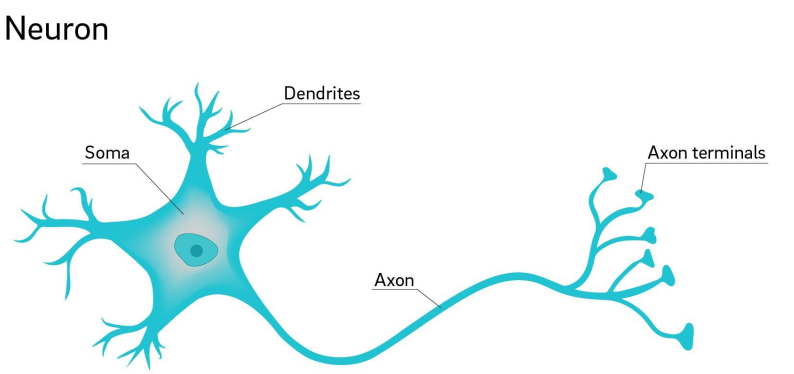
POLITECNICO
DI TORINO

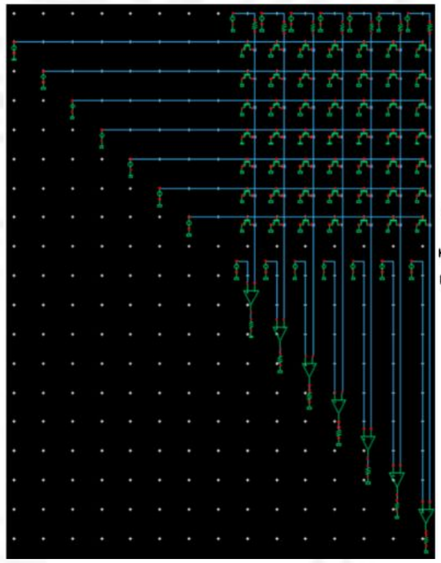
VLSI LAB
NANOCOMPUTING

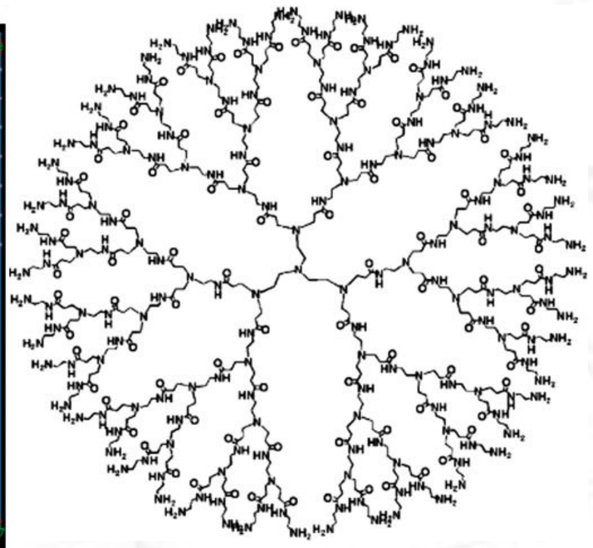
T.MOL.9 Molecular Neural Systems based on molecular transistors

Object: Design of a single-neuron and of a simple neural network with molecular technology

- Literature review of ANNs architectures and molecular devices with particular attention to neural network interesting features
- Development and design of a single neuron and neuron weights by means of a molecular transistor (MOLFET) technology
- Design of a molecular neural network with a hierarchical approach for reliable interfacing of neurons







POLITECNICO DI TORINO

VERY CHALLENGING

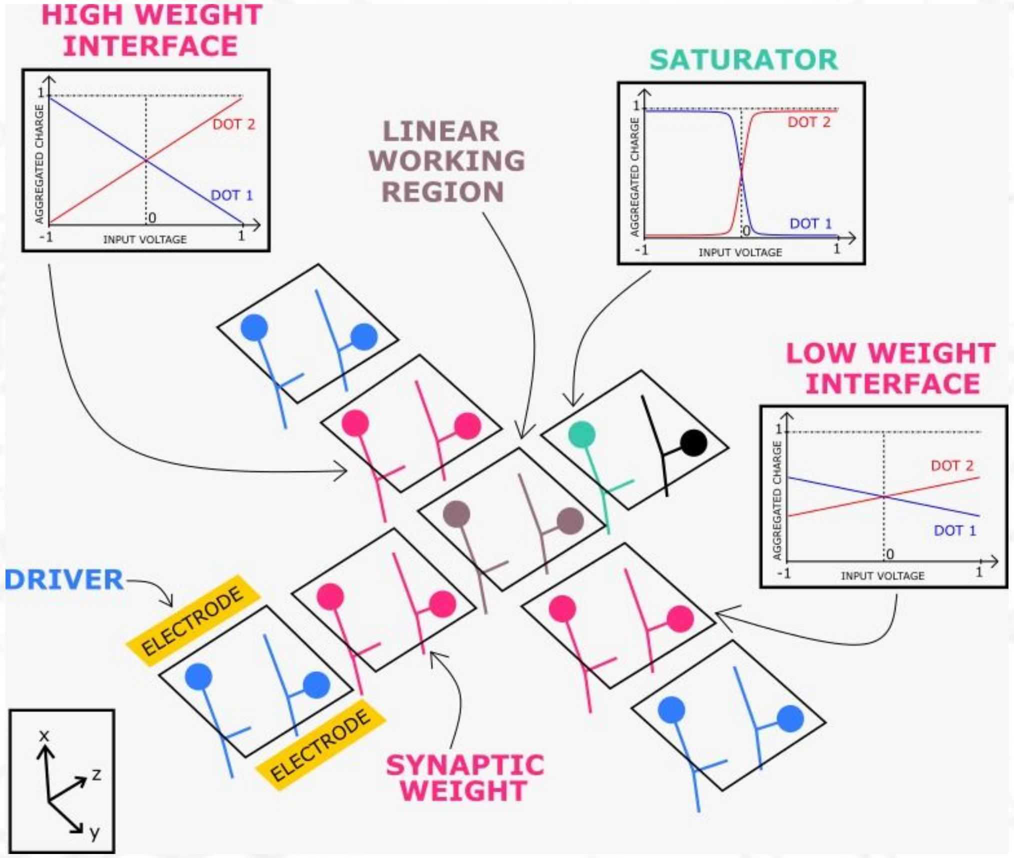
VLSI LAB NANOCOMPUTING

T.MOL.9 Molecular Neural Systems based on molecular transistors

Object: Design of a single-neuron and of a simple neural network with molecular technology

- Integration of the developed structure with conventional and innovative electronic systems and identification of practical application fields

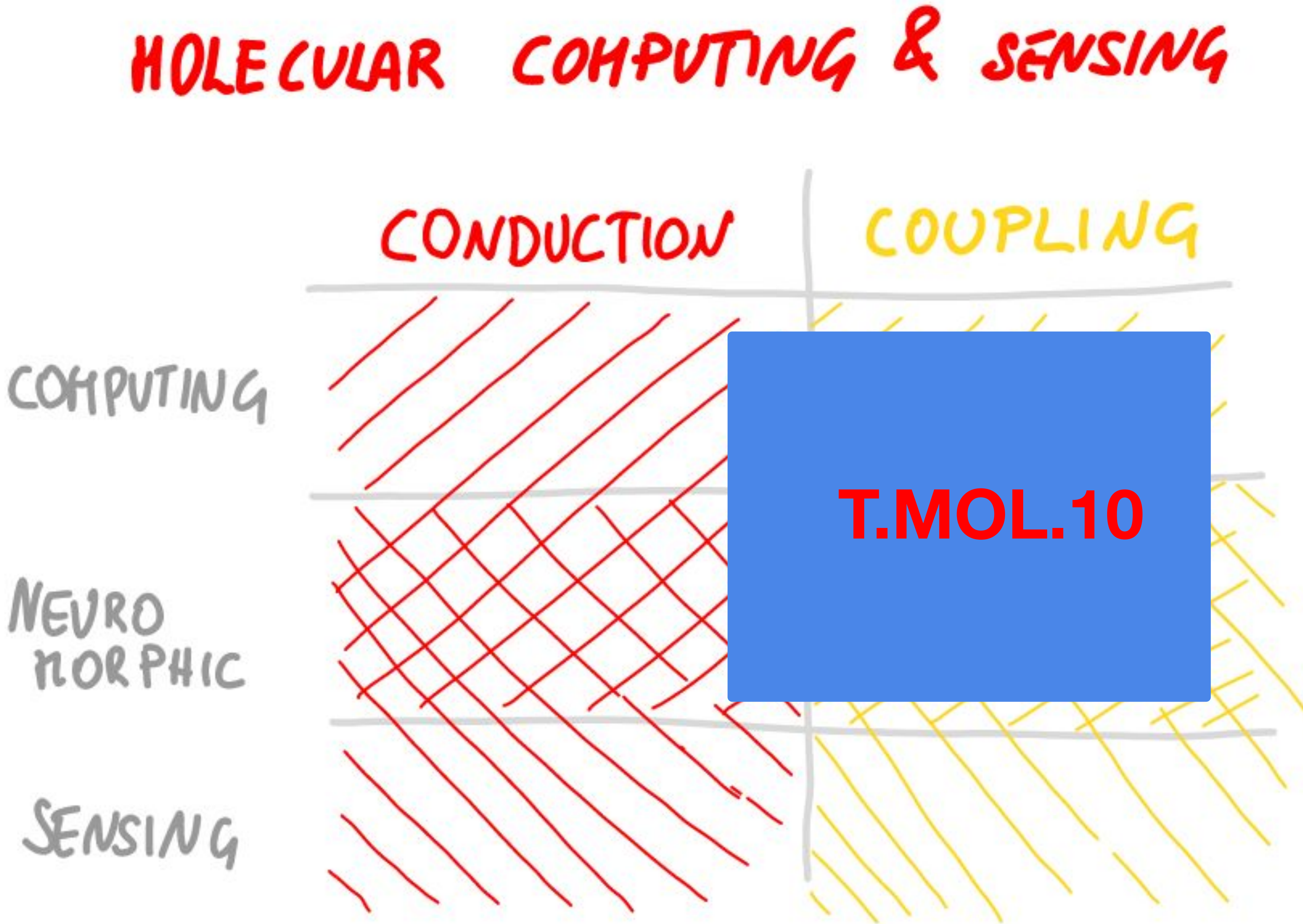
- Investigation of possible solution for molecular FCN-based neurons and investigation of the weightening strategies for molecular FCN technologies



VERY CHALLENGING

POLITECNICO DI TORINO

VLSI LAB NANOCOMPUTING



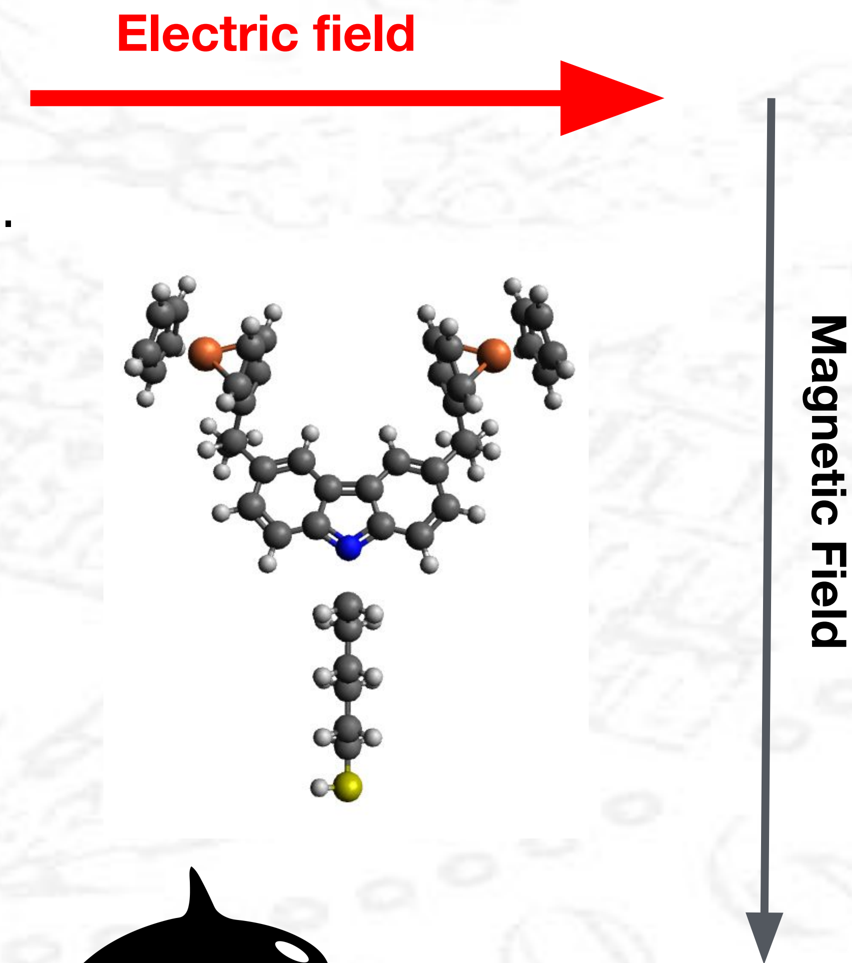
POLITECNICO DI TORINO

NANOCOMPUTING

T.MOL.10 Study the effects of magnetic fields on molecules

Object: Investigate whether and how magnetic fields (static/dynamic) influence molecule behavior and characteristics

In molecular Field-Coupled Nanocomputing, information encoding and propagation are strictly related to electrostatics. Having the possibility to add other degrees of freedom through magnetic fields may alter molecule characteristics.

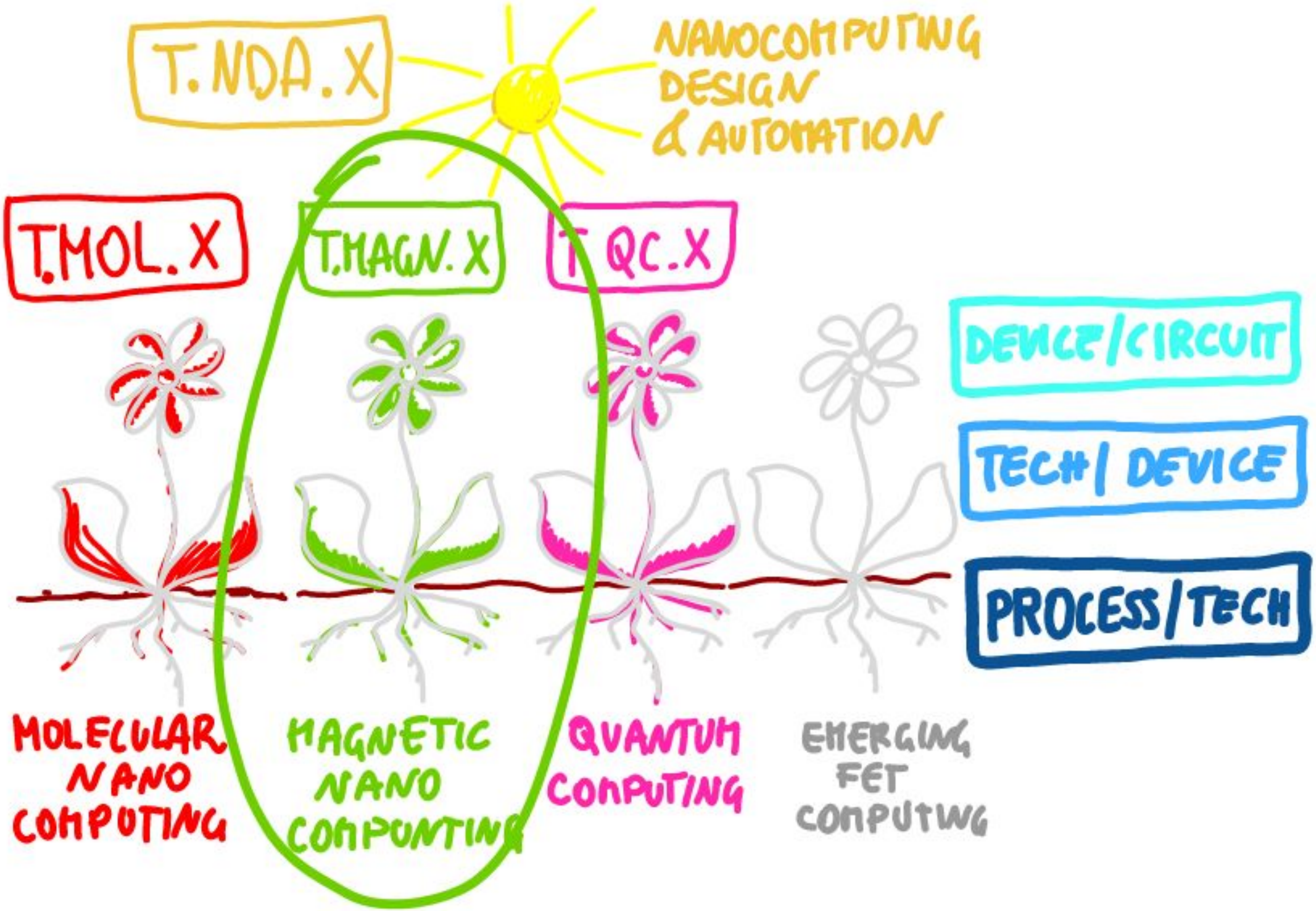


- Study of ab initio techniques used to analyse the magnetic properties of molecules and effects of magnetic field on charge distribution (MRCI and CASSCF modules of ORCA)
- Analysis of simple molecules under the effect of static magnetic field
- Analysis of dynamic magnetic fields applied to molecules

ORCA

POLITECNICO DI TORINO

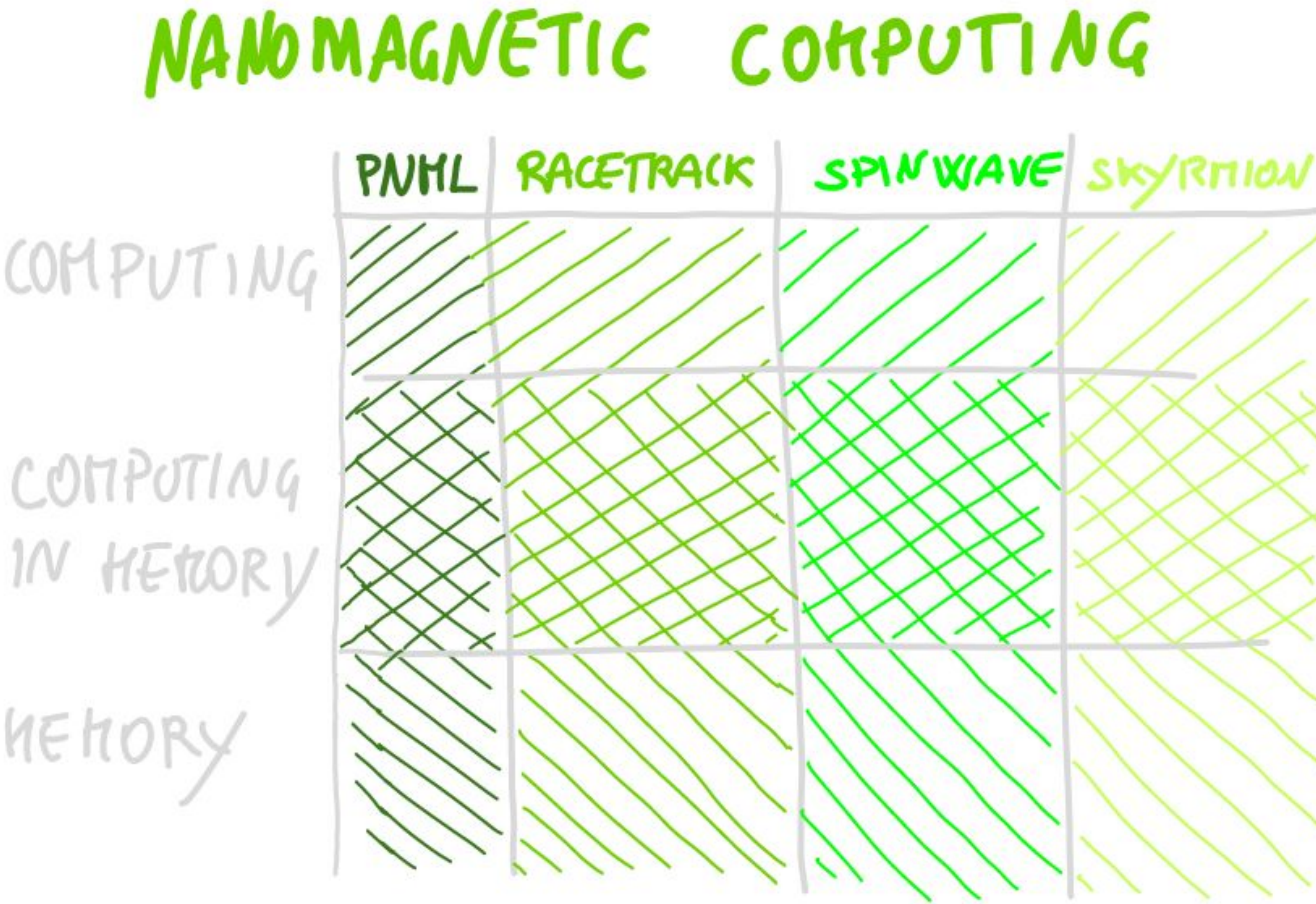
VLSI LAB NANOCOMPUTING



POLITECNICO DI TORINO

NANOCOMPUTING

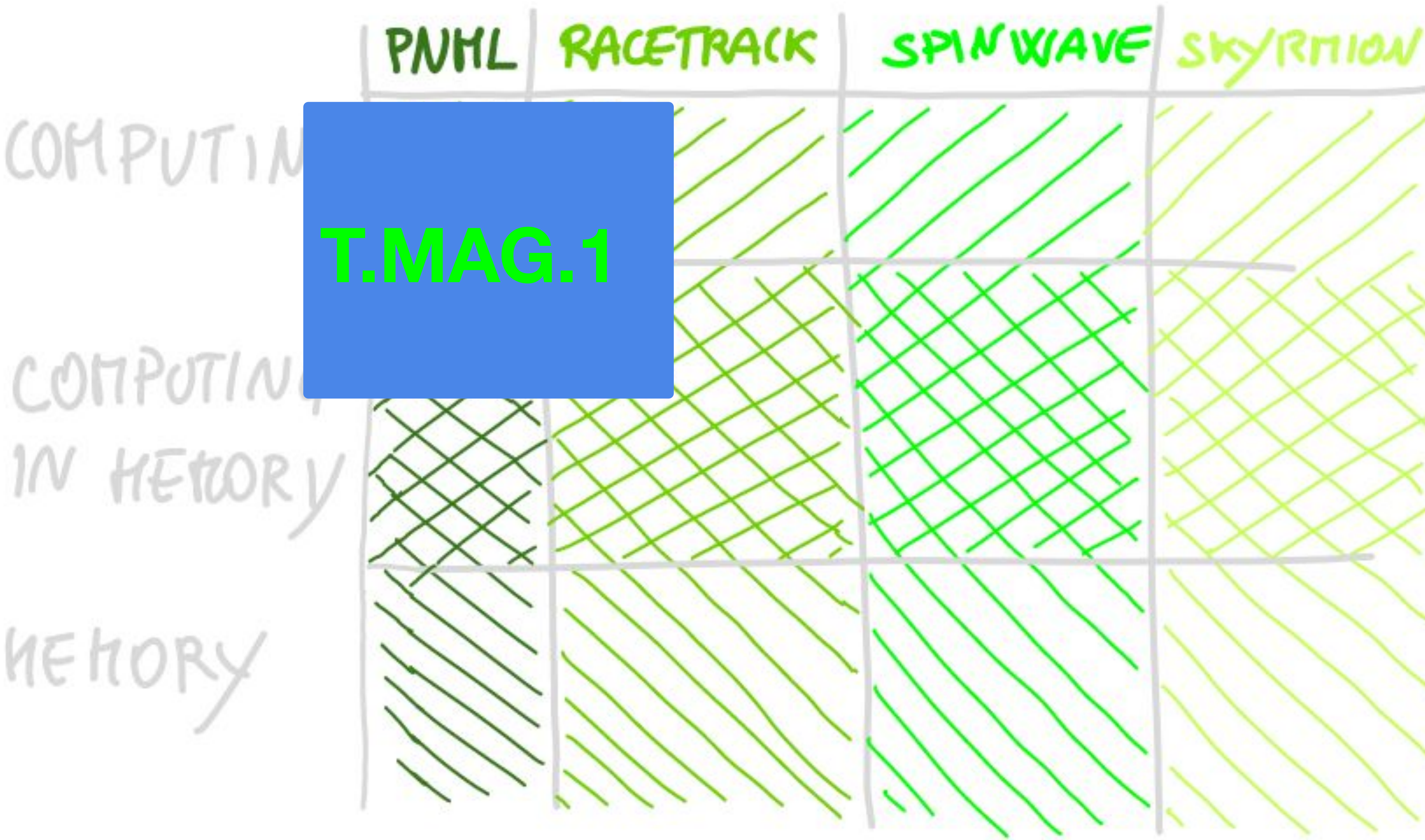
An inner MAP: technologies & applications



POLITECNICO DI TORINO

VLSI LAB NANOCOMPUTING

NANOMAGNETIC COMPUTING



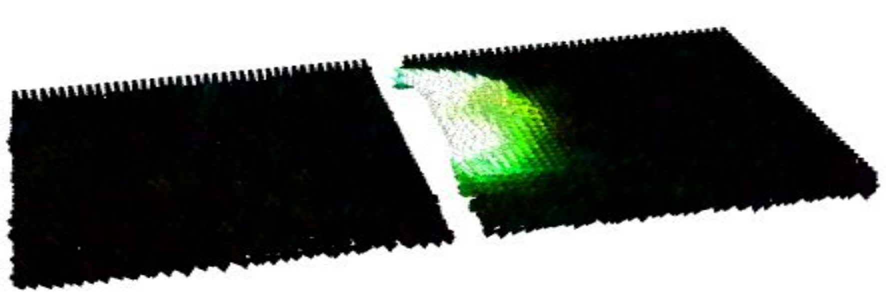
POLITECNICO DI TORINO

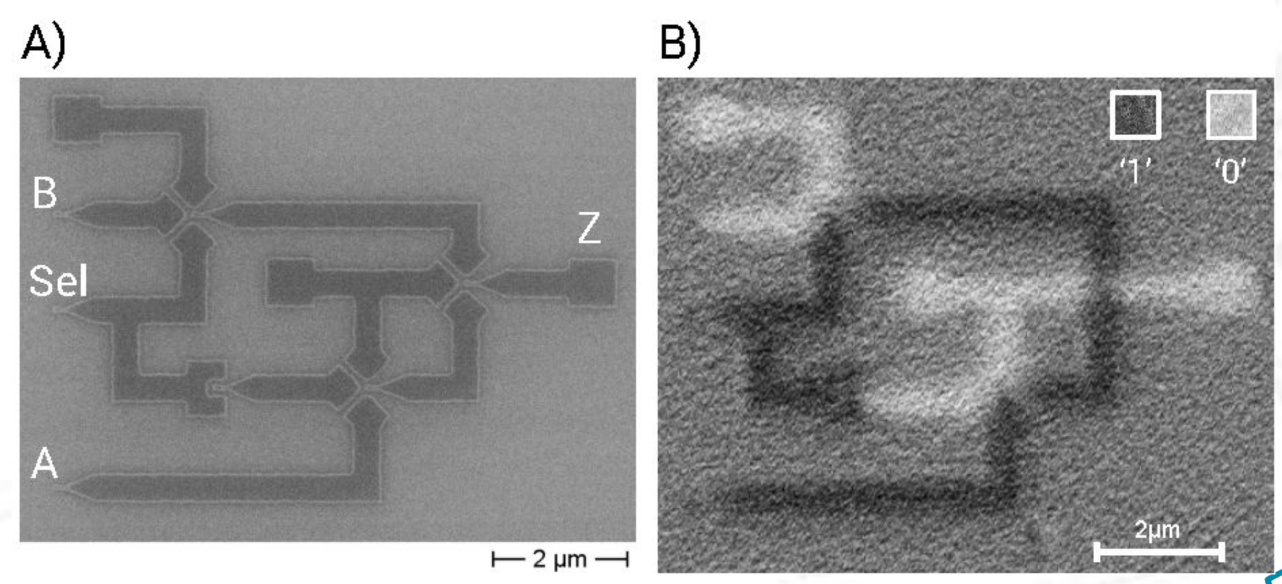
VLSI LAB NANOCOMPUTING

T.MAG.1 Design of an efficient on-chip clocking system

Object: Design and characterization of an efficient on-chip clocking system for the generation of perpendicular fields

- perpendicular Nano Magnetic Logic (pNML) is based on material with strong Perpendicular Magnetic Anisotropy (PMA)
- Usually make in Co/Pt and Co/Ni
- Required a soft PMA spot to control the domain wall nucleation
- Switching is achieve by the superposition of field coupling

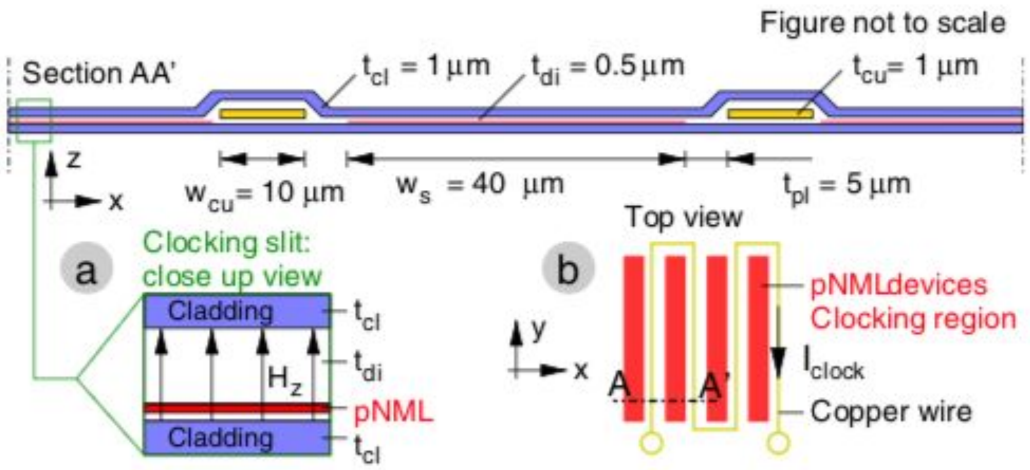




T.MAG.1 Design of an efficient on-chip clocking system

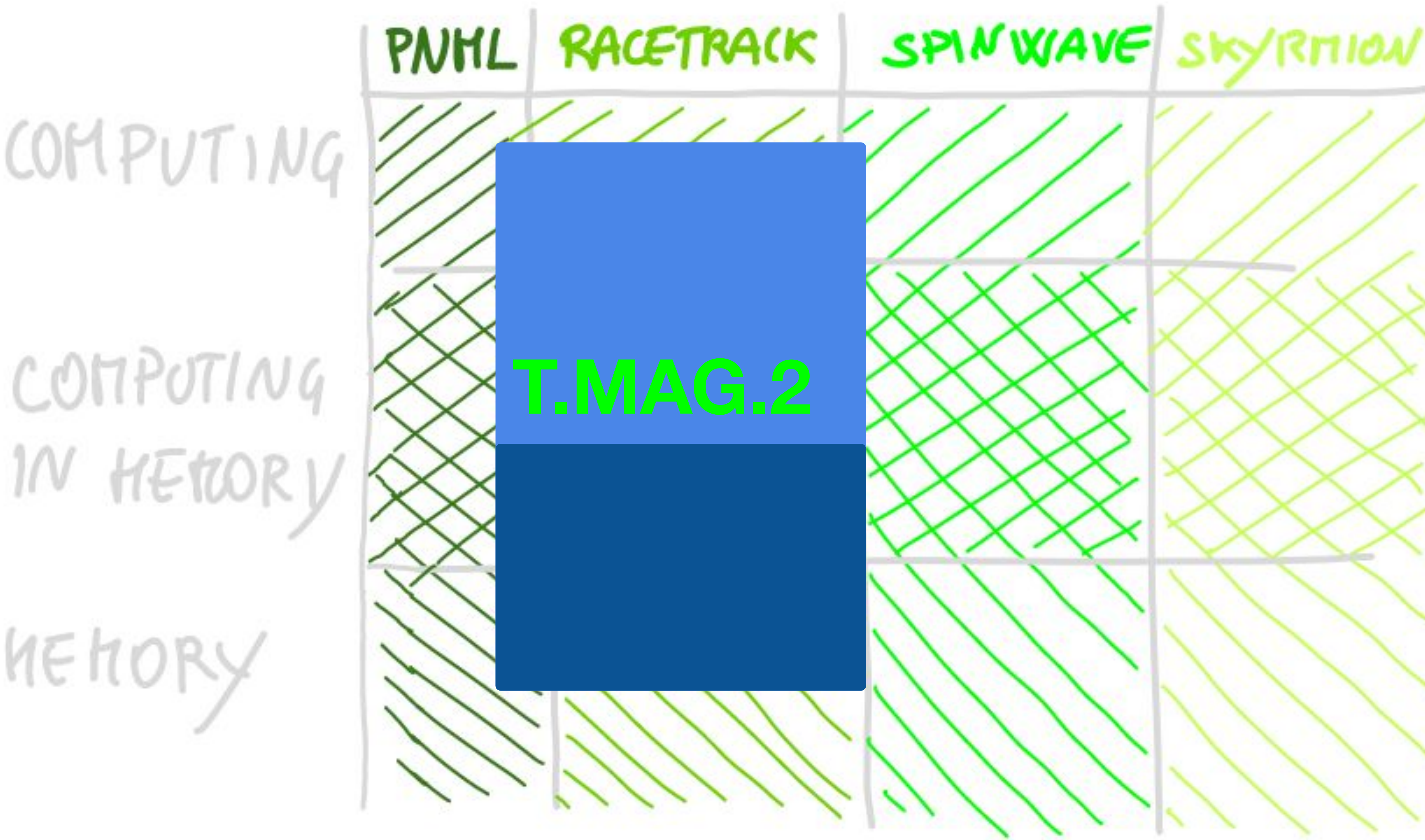
Object: Design and characterization of an efficient on-chip clocking system for the generation of perpendicular fields

- The aim is to design an on-chip coil that requires a simple process and generates an homogenous out of plane field (pNML)
- Simulate the designed clocking system with COMSOL considering power losses with different cladding materials and copper windings
- Evaluate the losses at different operating frequencies. The power losses from the control circuitry when generating positive and negative pulses need to be considered



POLITECNICO DI TORINO

NANOMAGNETIC COMPUTING



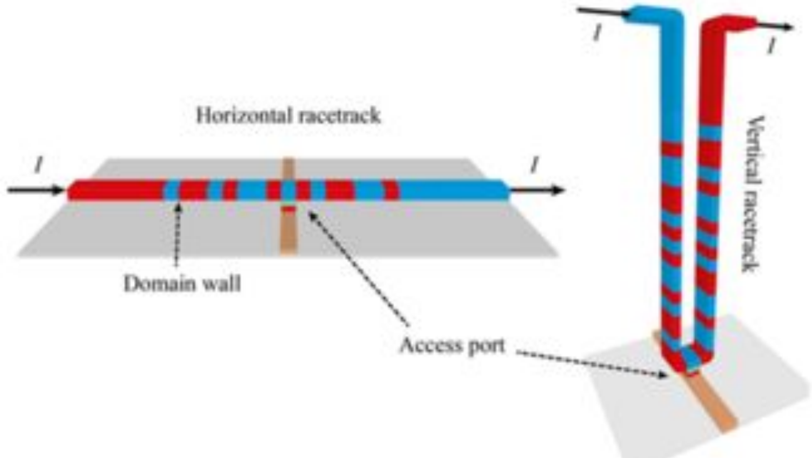
POLITECNICO DI TORINO

VLSI LAB NANOCOMPUTING

T.MAG.2 Development of the racetrack logic technology

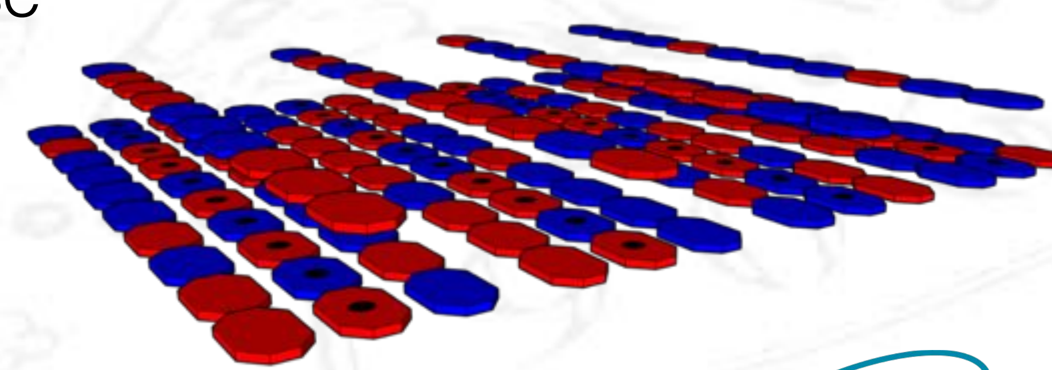
Object: Design of threshold logic gates by controlling dynamically the magnetic anisotropy

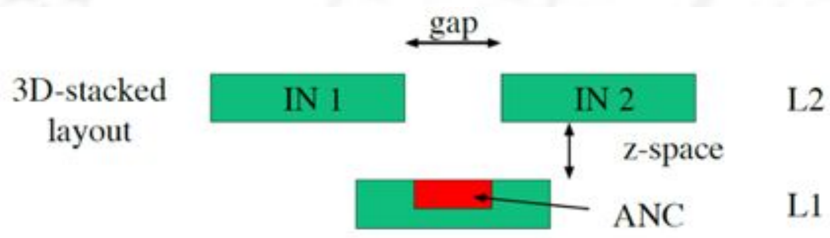
- Study CoFeB/MgO stacks
- Study the behavior of Artificial Nucleation Centers on magnetic island
- Design and characterization of the developed logic gates
- Investigate potential applications that can benefit from this highly structure performing bit-wise operations



R. Bläsing *et al.*, "Magnetic Racetrack Memory: From Physics to the Cusp of Applications Within a Decade," Aug. 2020

mumax3

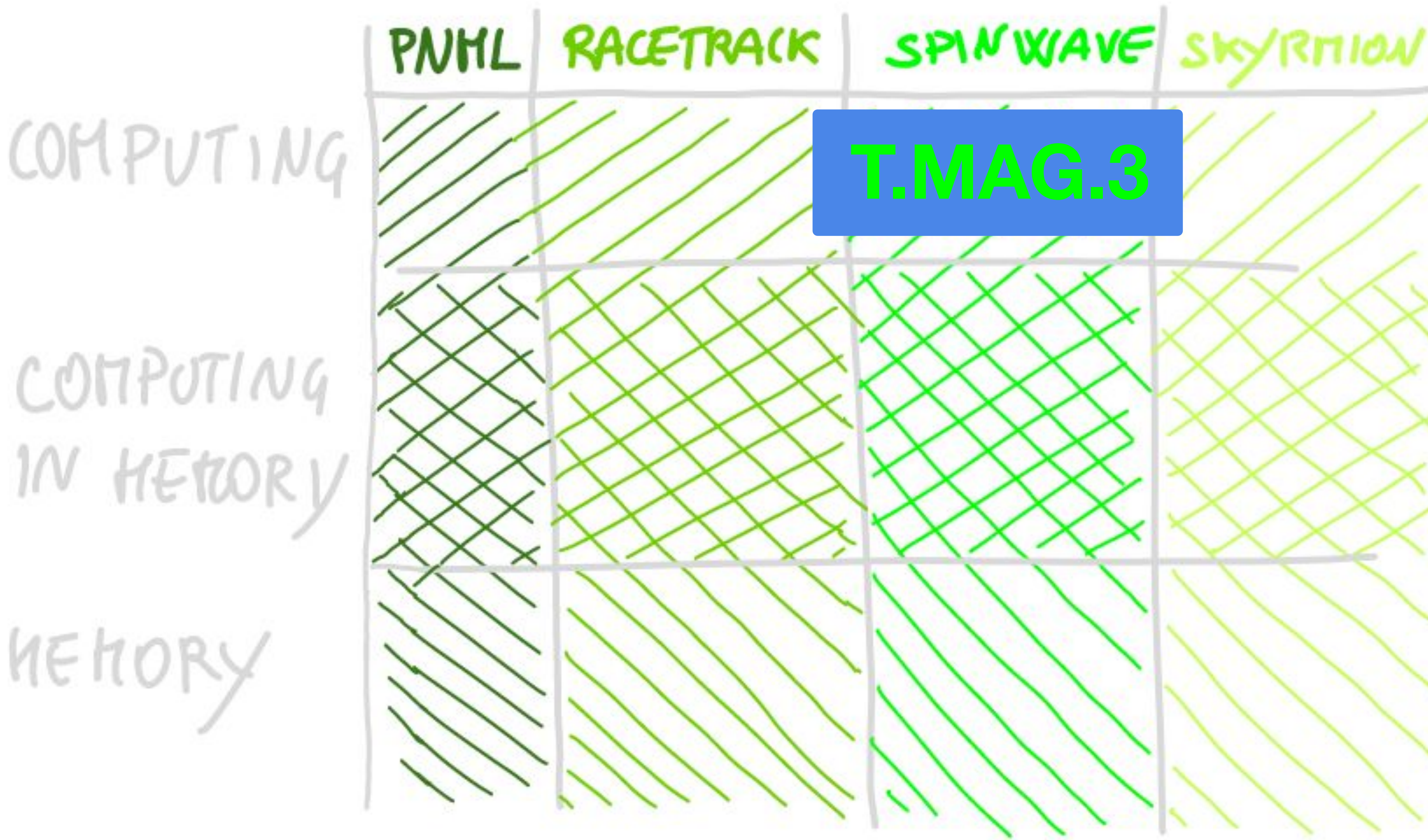




POLITECNICO DI TORINO

NANOCOMPUTING

NANOMAGNETIC COMPUTING



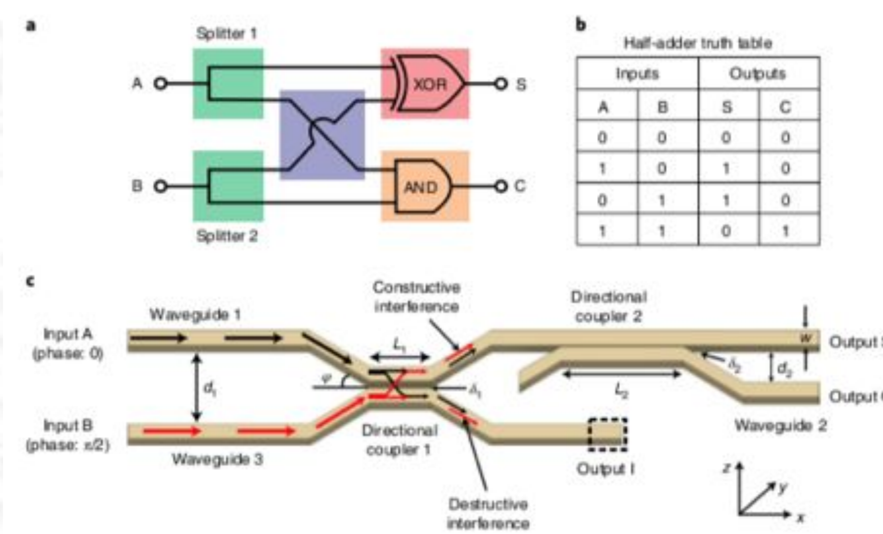
POLITECNICO DI TORINO

VLSI LAB NANOCOMPUTING

T.MAG.3 Development of a Compact Model for Spinwaves Simulatons

Object: Development of a compact model in Verilog-A for the simulations of circuits based on Spinwaves

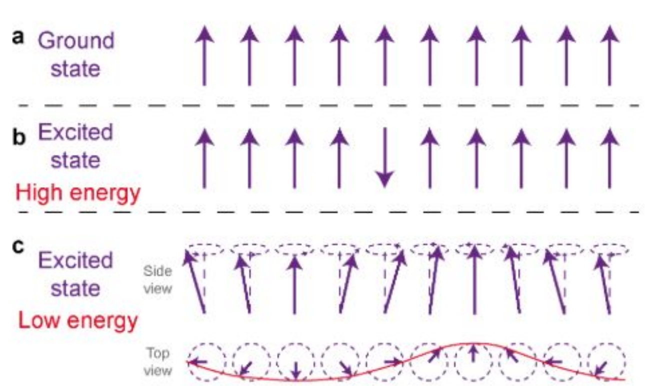
- Study the spinwave technology for its applicability for logic computation
- Develop a compact model in Verilog-A (Cadence Virtuoso) of every building blocks
- Model validation and performance evaluation of complex systems with respect to state of the art CMOS

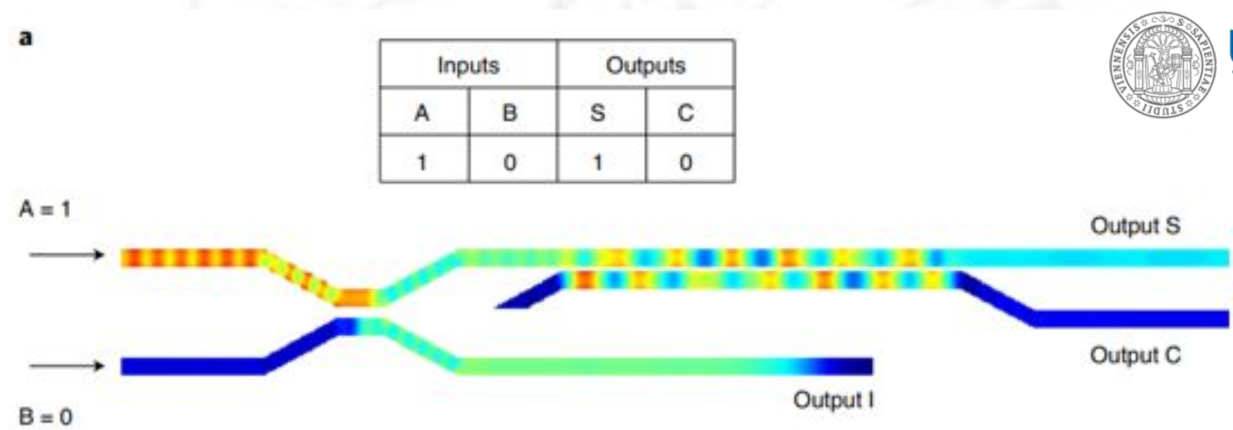


Wang, Q. *et al.* A magnonic directional coupler for integrated magnonic half-adders. *Nat Electron* (2020)

Custom IC Design Virtuoso cādence

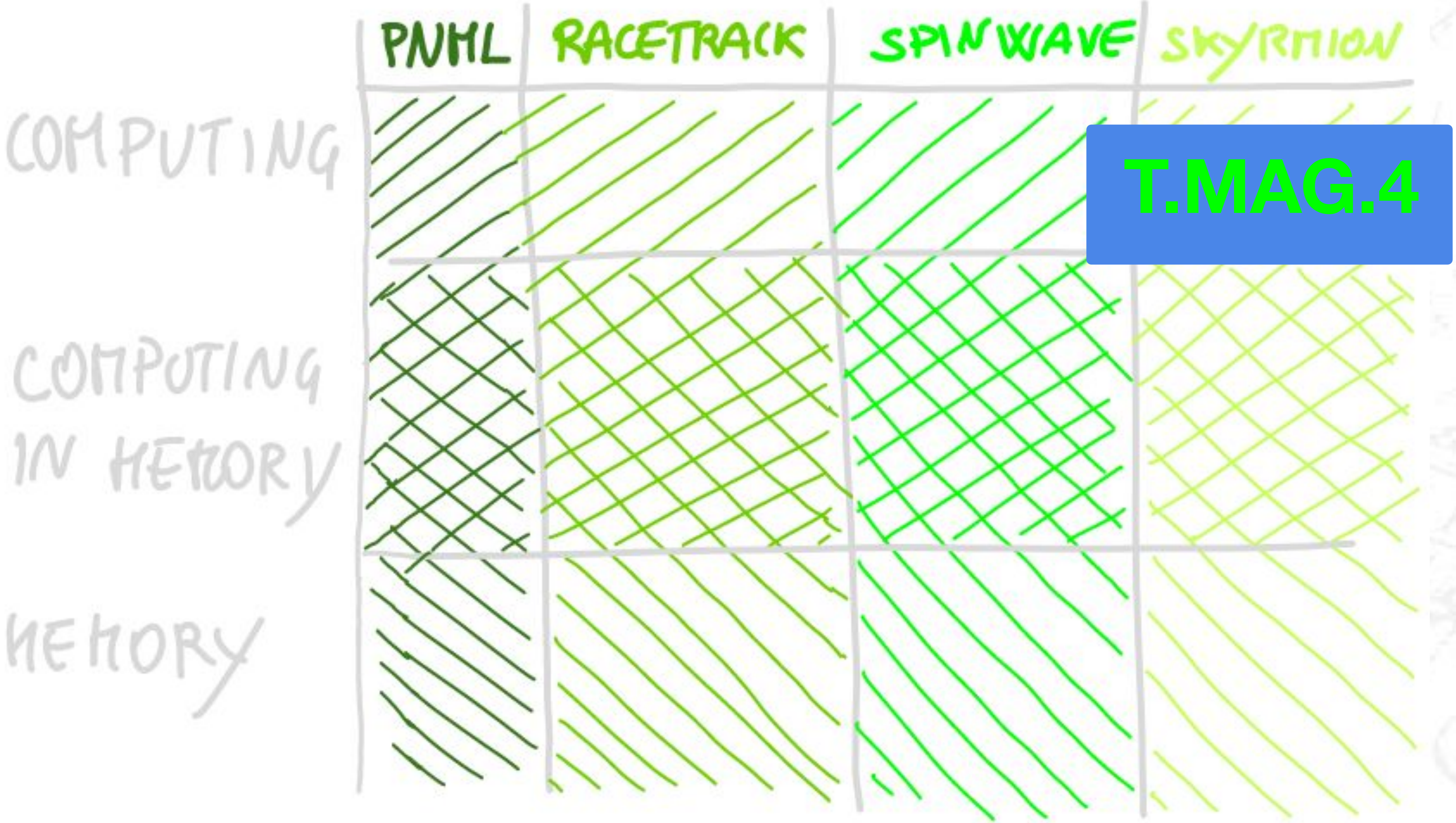
universität wien





VLSI LAB NANOCOMPUTING

NANOMAGNETIC COMPUTING



POLITECNICO DI TORINO

VLSI LAB NANOCOMPUTING

T.MAG.4 Characterization and modeling of standard blocks for skyrmion logic

Object: Definition and study of standard basic blocks for skyrmion computing systems

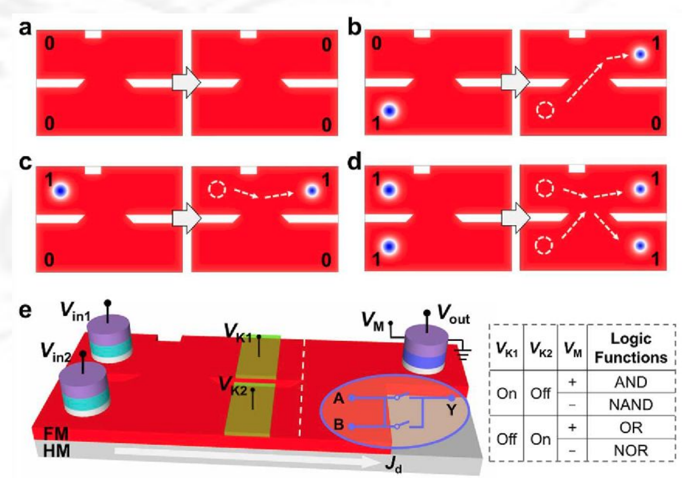
- Study of state of the art devices based on skyrmion for logic purposes
- Definition of a complete set of operations for logic based on skyrmion
- Simlation and characterization of the basic blocks of the defined set

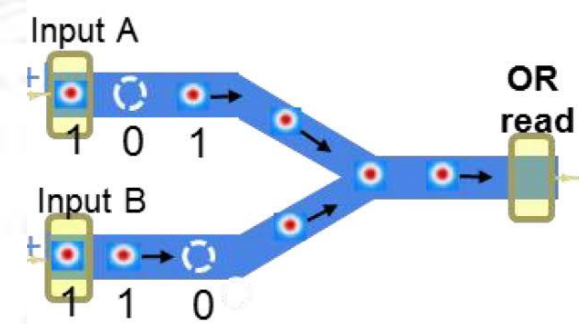
Physical Simulation

Elmer mumax3

Advanced work:

- Analytical modeling of the defined basic blocks

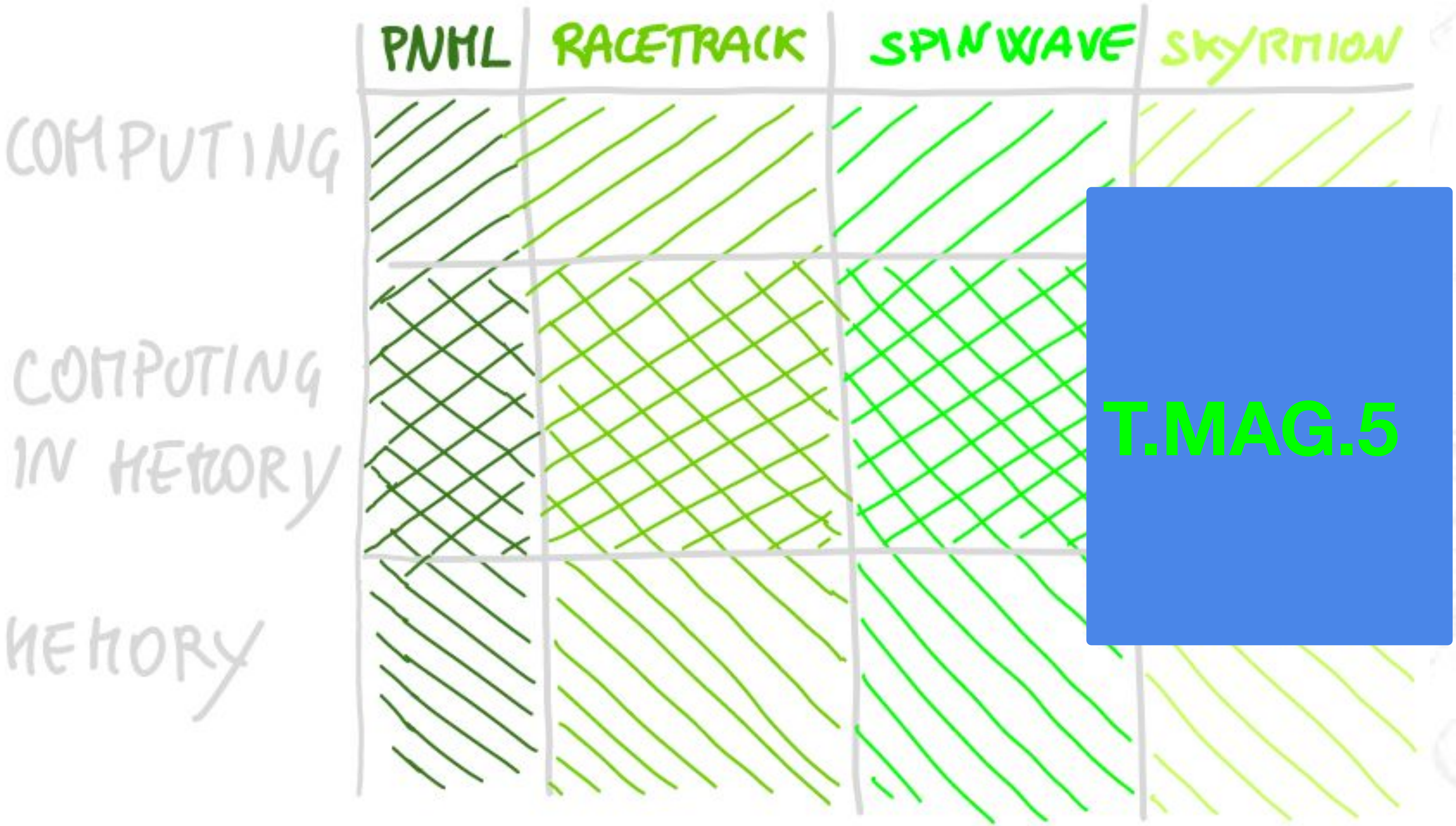




POLITECNICO DI TORINO

VLSI LAB NANOCOMPUTING

NANOMAGNETIC COMPUTING



POLITECNICO DI TORINO

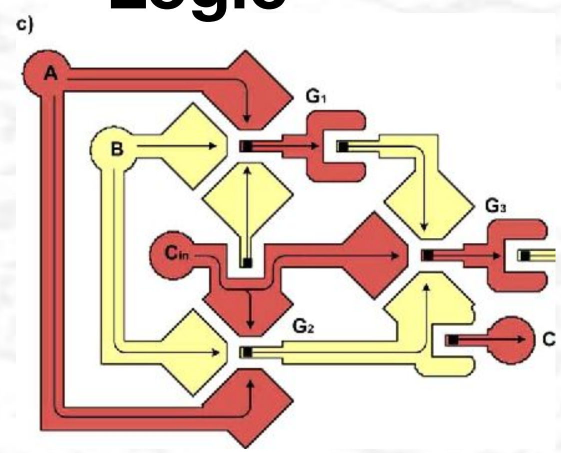
VLSI LAB
NANOCOMPUTING

T.MAG.5 Hybrid PNML-Skyrmion systems

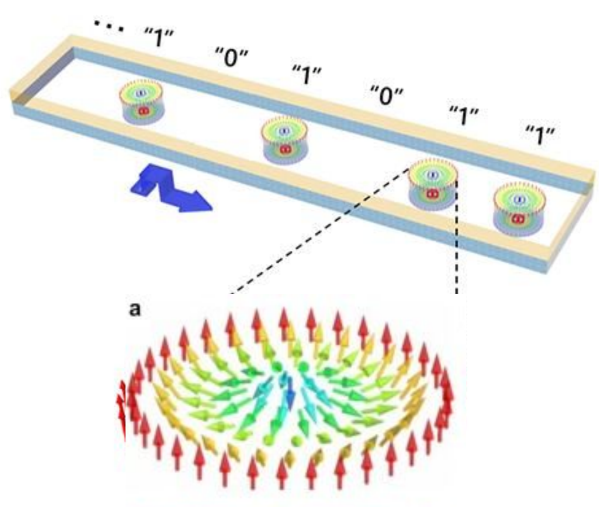
Object: Design and evaluation of complex logic in memory skyrmion magnetic systems for in-memory computing

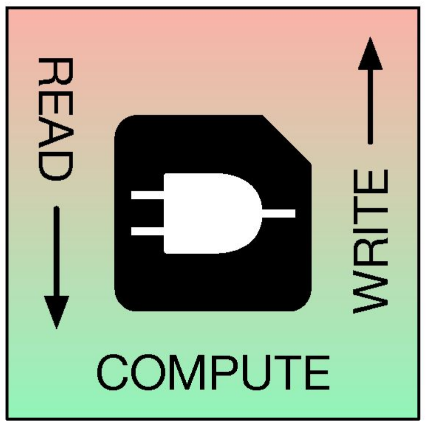
- Exploration of ferromagnetic materials hosting skyrmion and compatible with PNML technology
- Simulation and modelling of interface device in the chosen material
- Algorithm exploration suitable for hybrid spintronic systems
- Evaluation of performance of one or few case study

Logic



Memory

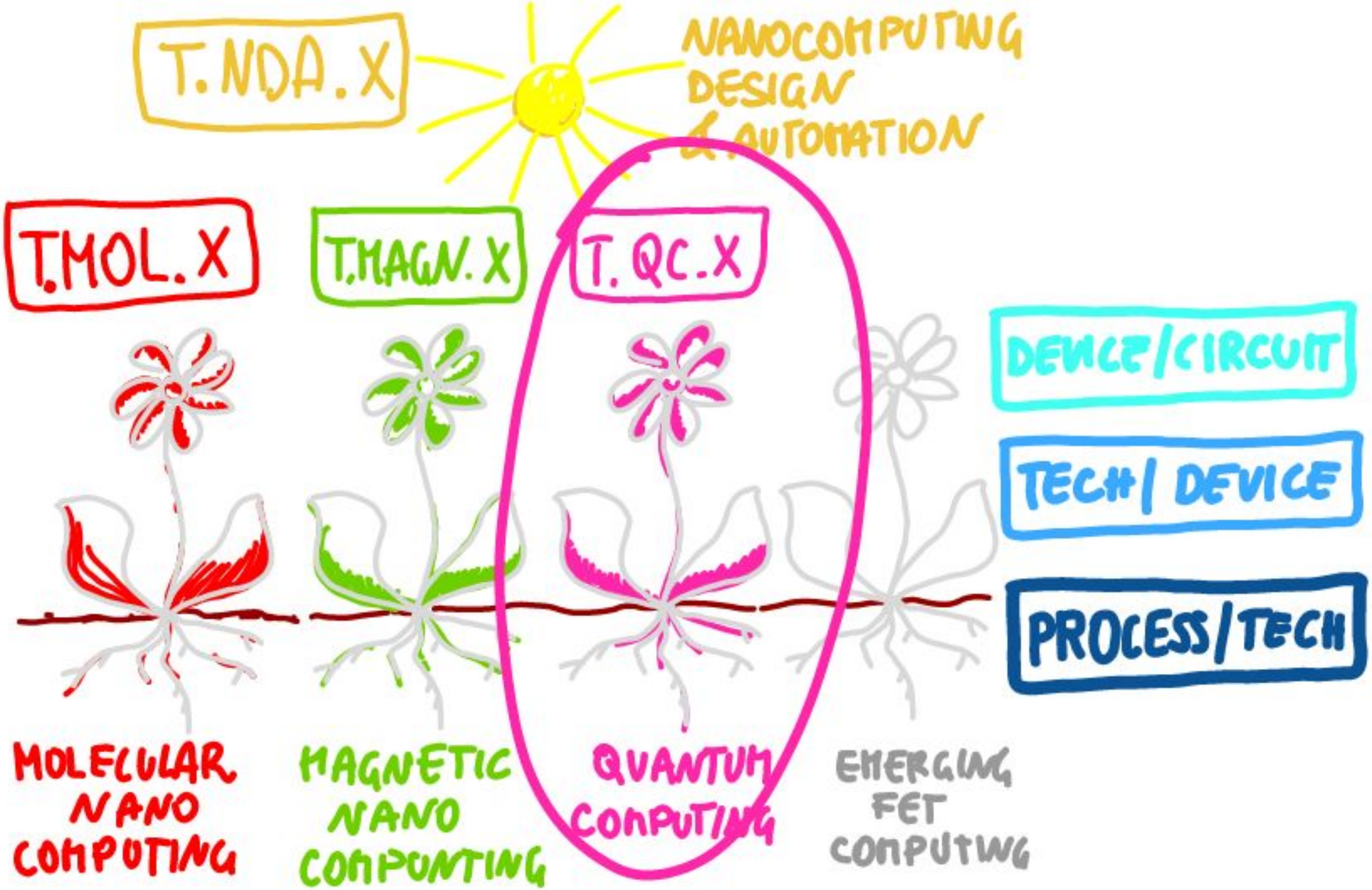




Logic-in-Memory

POLITECNICO DI TORINO

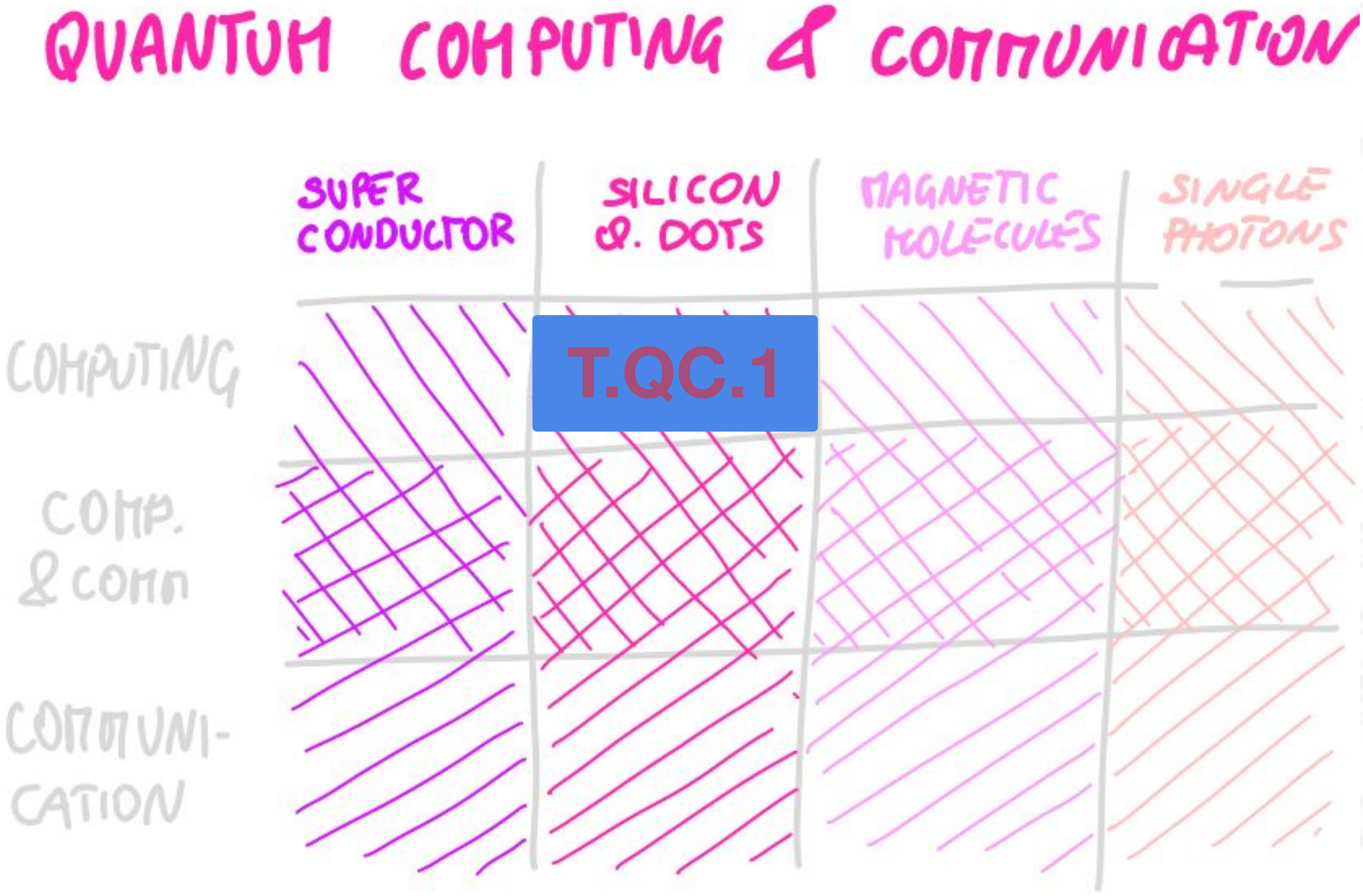
VLSI LAB NANOCOMPUTING



POLITECNICO DI TORINO

NANOCOMPUTING

An inner MAP: technologies & applications



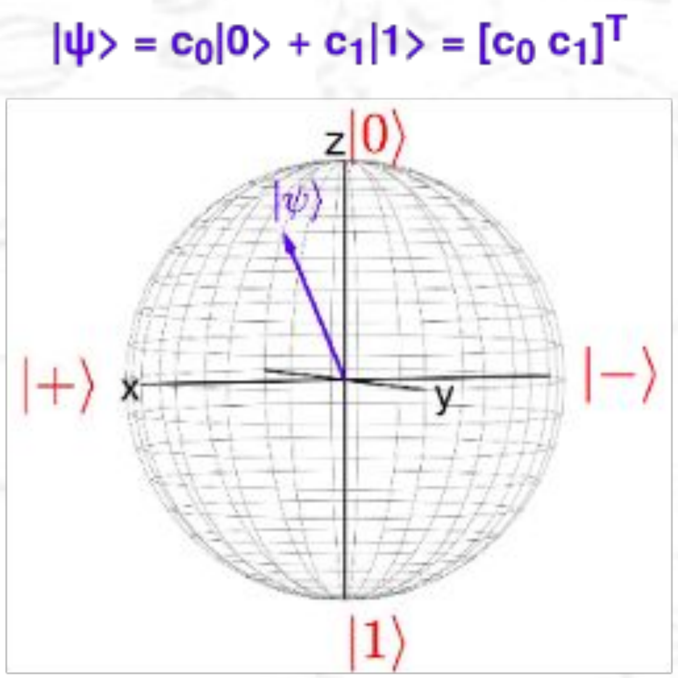
POLITECNICO DI TORINO

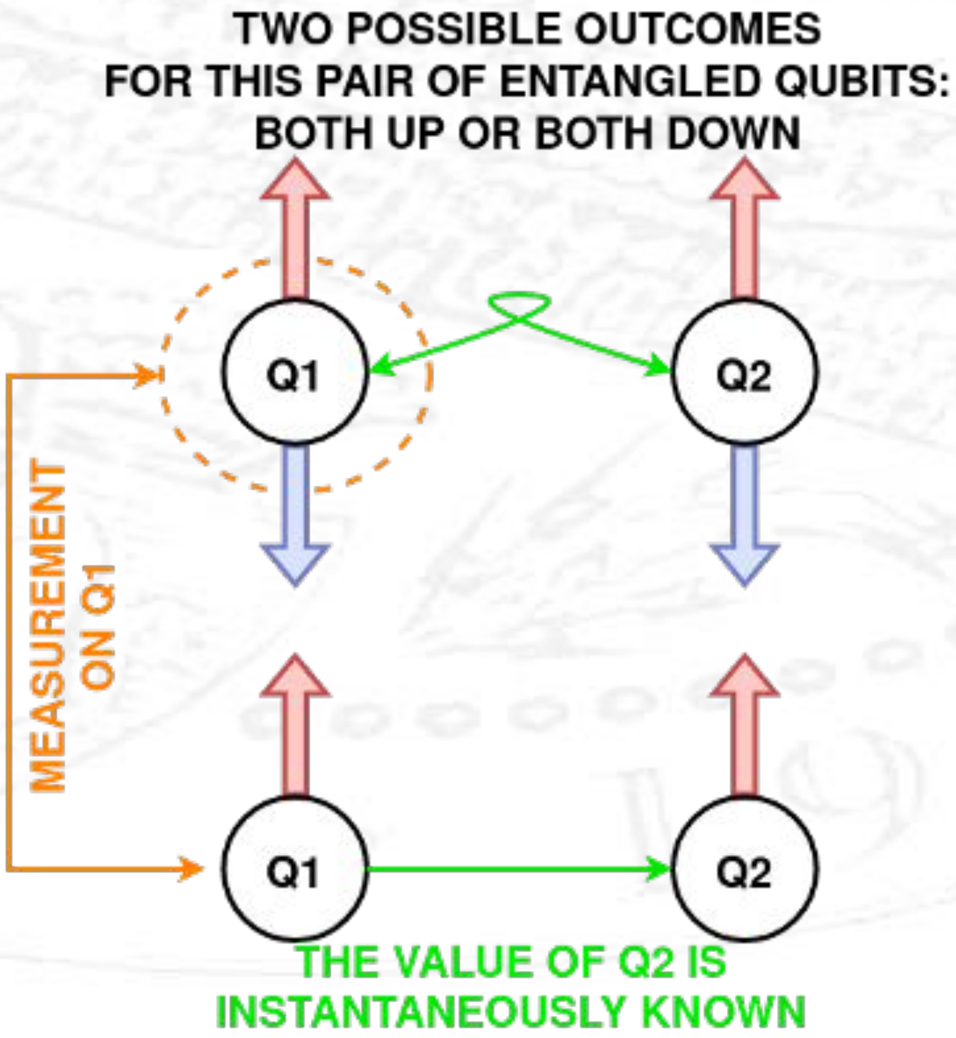
NANOCOMPUTING

Quantum Information

- Quantum Information is a discipline of Information Theory related to the analysis and the design of computational and communication protocols based on a unit of information, named **qubit**, encoded onto a quantum physical quantity.

- Quantum physical properties as **superposition** and **entanglement** permit to define faster computation and safer communication protocols.





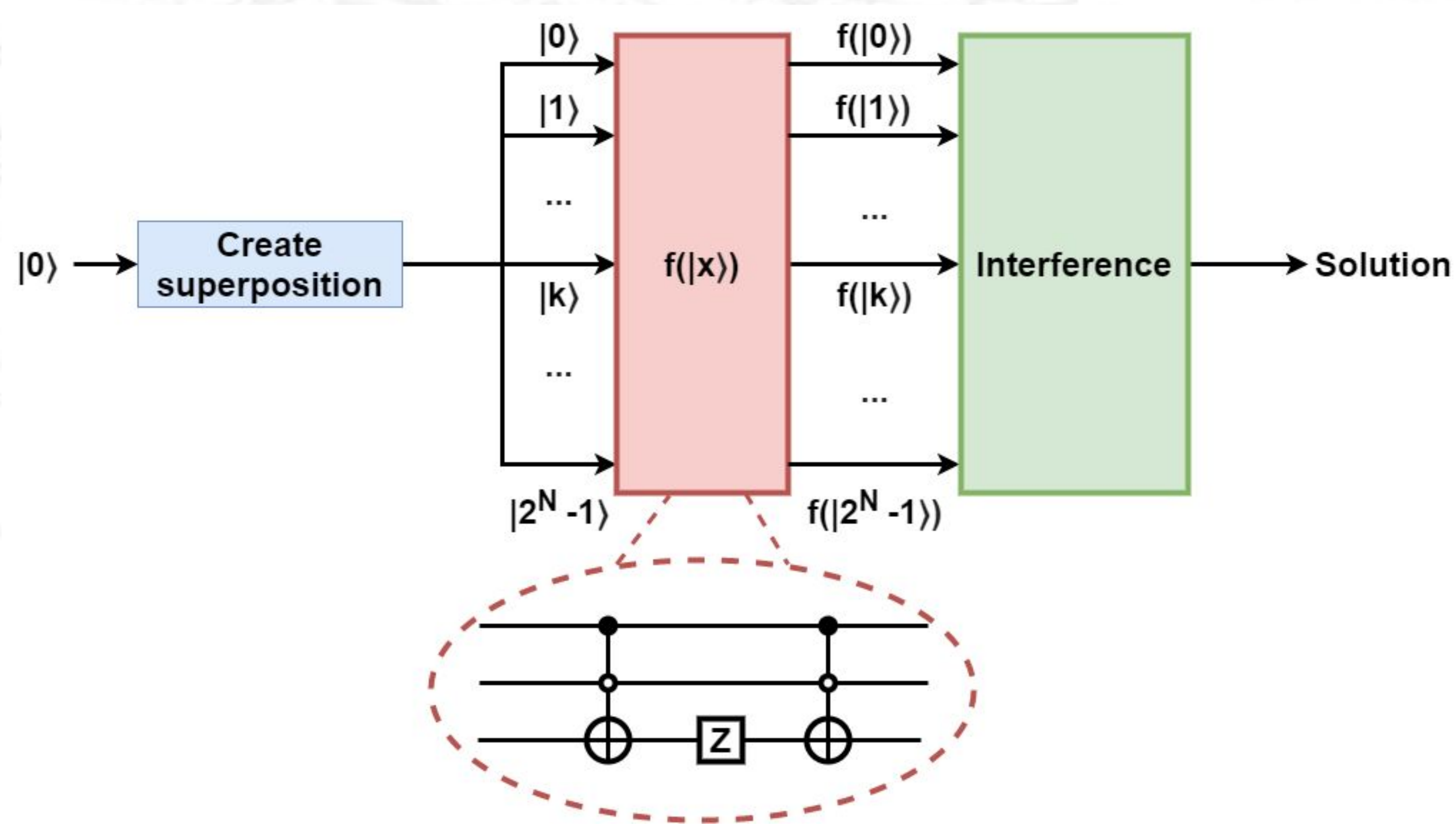
POLITECNICO DI TORINO

VLSI LAB NANOCOMPUTING

Quantum Computational Advantage

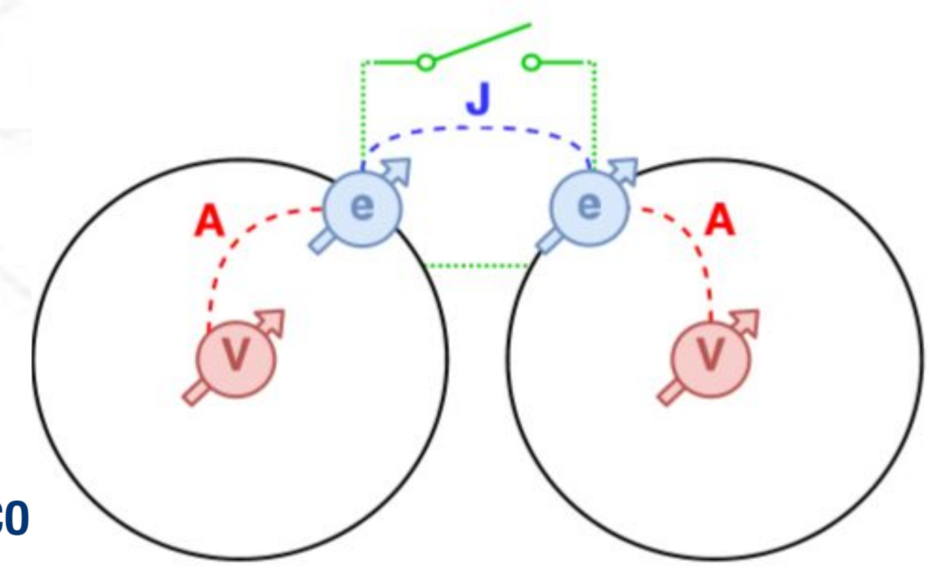
- **Superposition** permits to simultaneously evaluate multiple data
- **Entanglement** can assist in fast converging to the problem's solution.

They **both** permit to define, for some hard problems, algorithms with computational costs **lower** than the best corresponding classical ones.

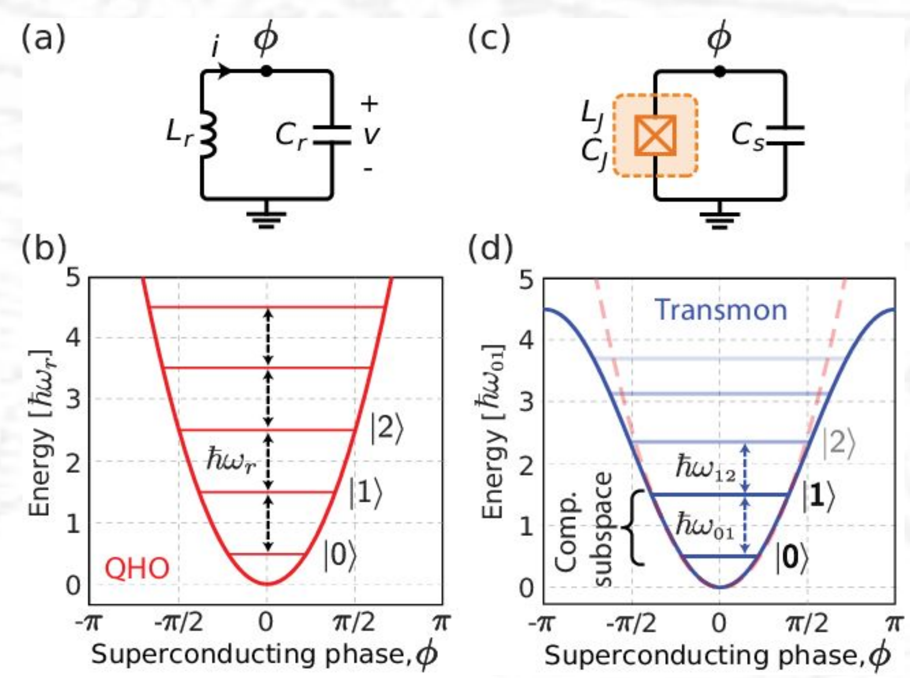


Hardware for Quantum Computing

- **Quantum Computing technologies** can significantly differ in terms of:
  - temperature;
  - magnetostatic fields;
  - bandwidth of EM signals employed for the implementation of quantum gates;
  - non-ideality (*e.g.* decoherence and relaxation) timescales;
  - native gates;
  - fabrication and maintenance costs.
- A system capable of evaluating the quality of a quantum circuit/algorithm on different quantum computers, taking always into account their pros and cons, is required.



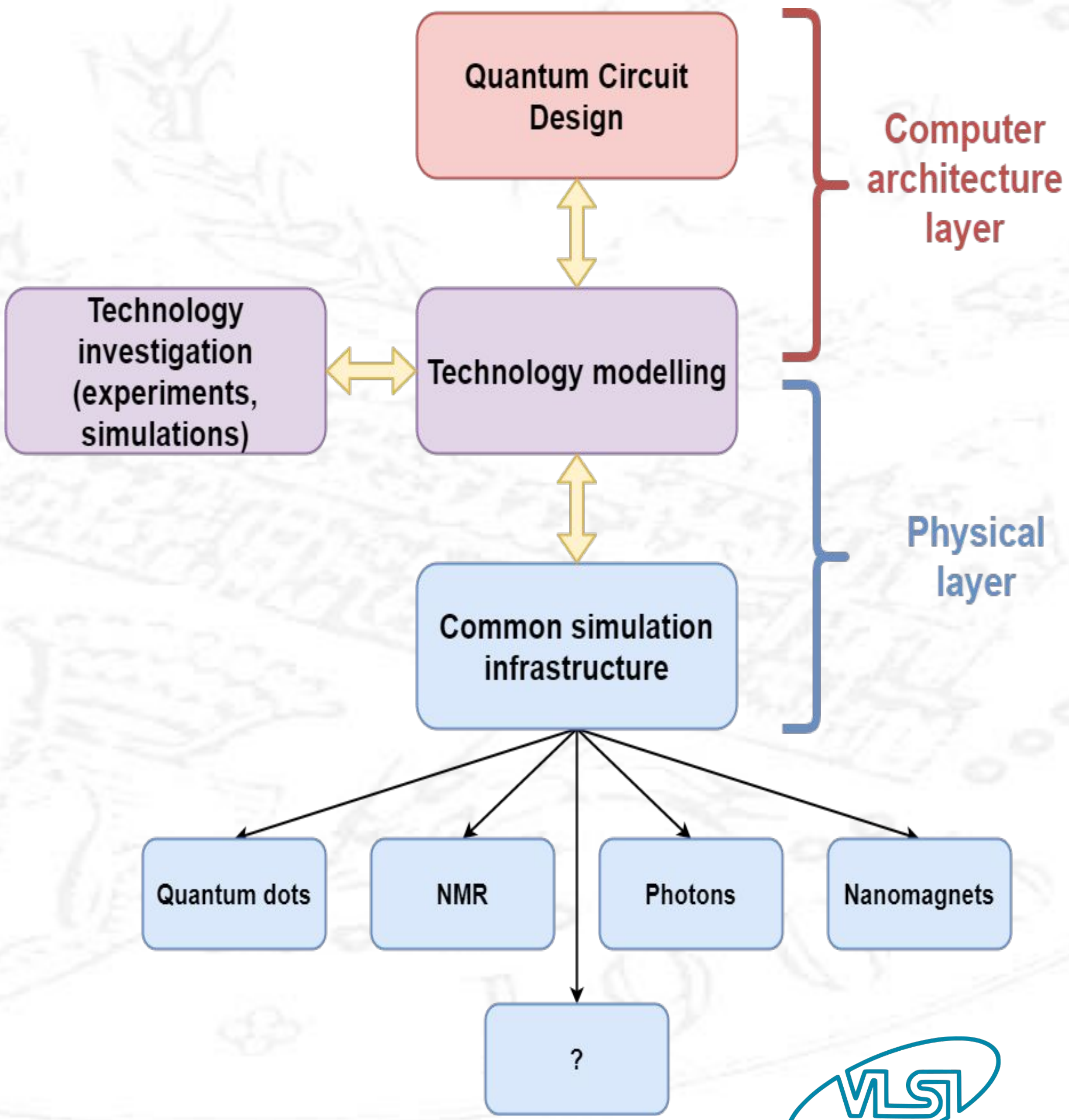
Cirillo, Turvani, Simoni and Graziano, *ISVLSI 2020*, 2020



Kranz *et al.*, Applied Physics Reviews **6**, 021318 (2019)

Methodology for analyzing a QC technology

- **Perspective:** development of a software tool for designing and comparing the execution of quantum circuits with different technologies.
- Description for each **technology** of a **compact model** involving its main physical properties.
- An optimized simulator for **non-ideal quantum** circuits is required.
- Current infrastructure is based on MATLAB.

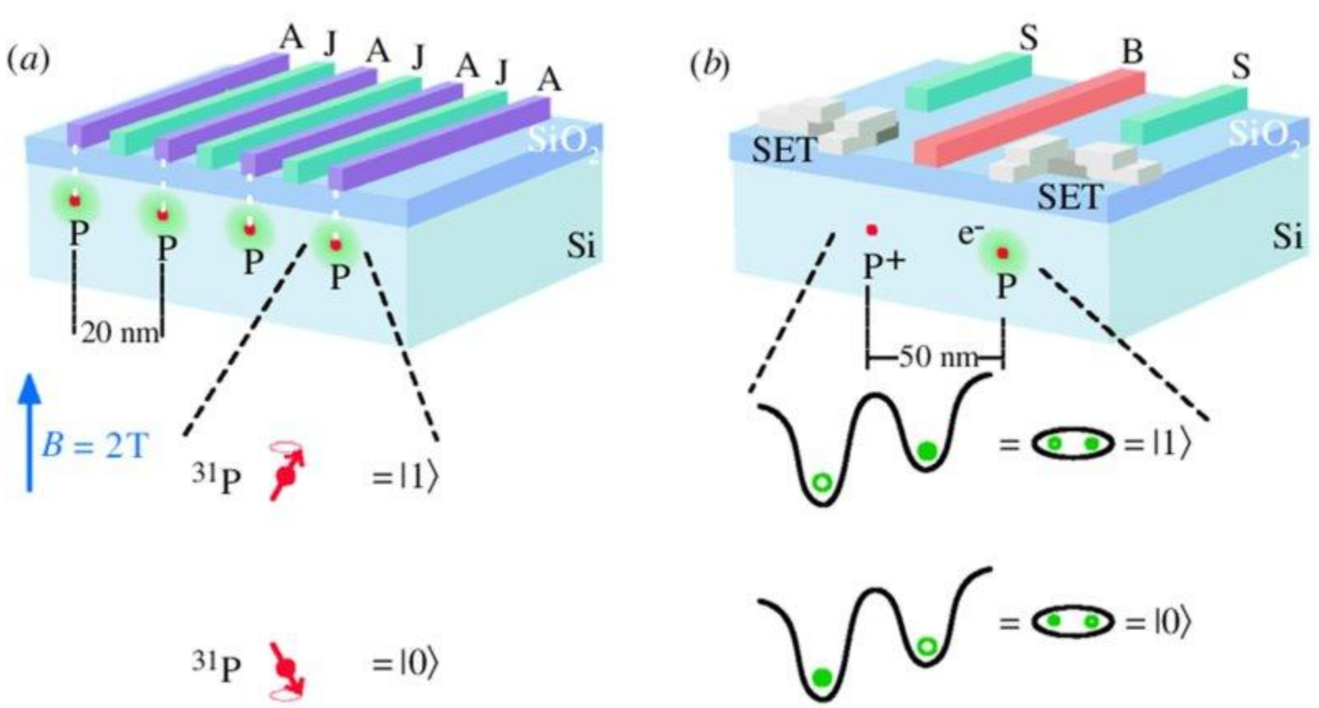


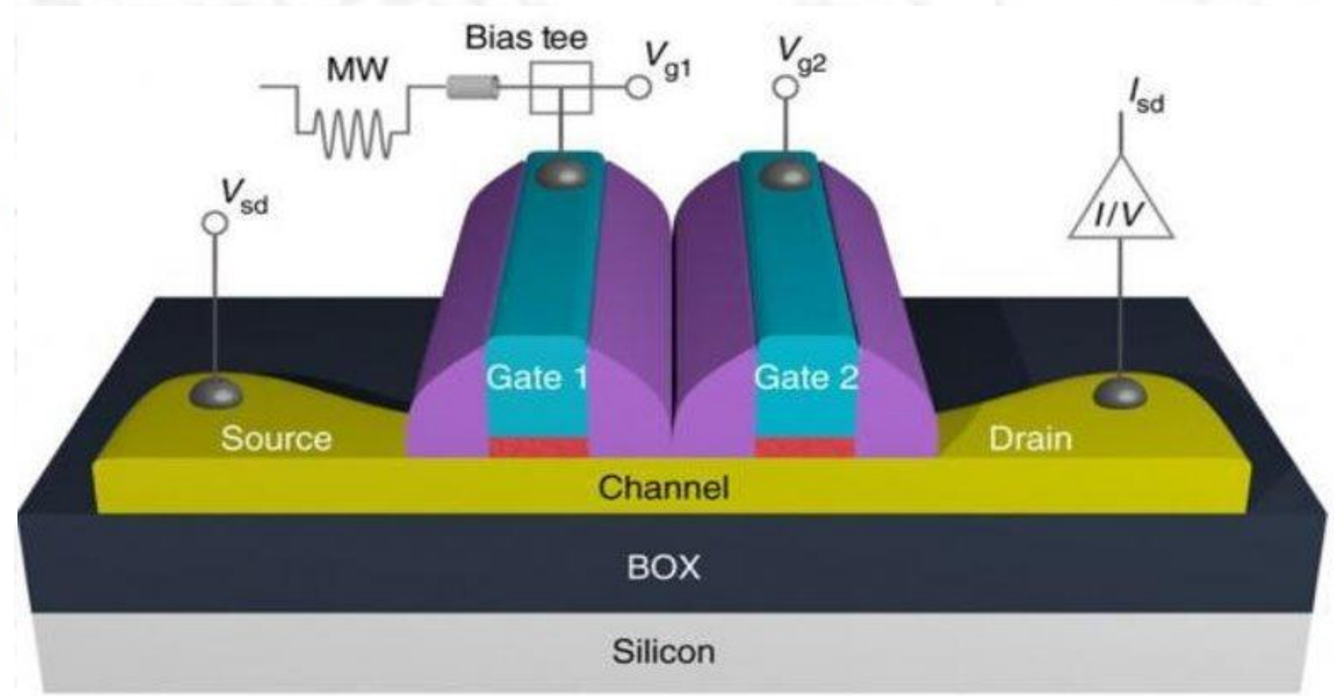
POLITECNICO DI TORINO

NANOCOMPUTING

T.QC.1: QC with Silicon Quantum-Dots

- **Solid-state** technology encoding quantum information on electron spins.
- Higher operating **temperature** than superconducting qubits (IBM).
- Potential easier **interface** with a classical computer and to photonic links.
- A two-qubit architecture of TU Delft is already programmable via-cloud.





POLITECNICO DI TORINO

VLSI LAB NANOCOMPUTING

T.QC.1: QC with Silicon Quantum-Dots

Article

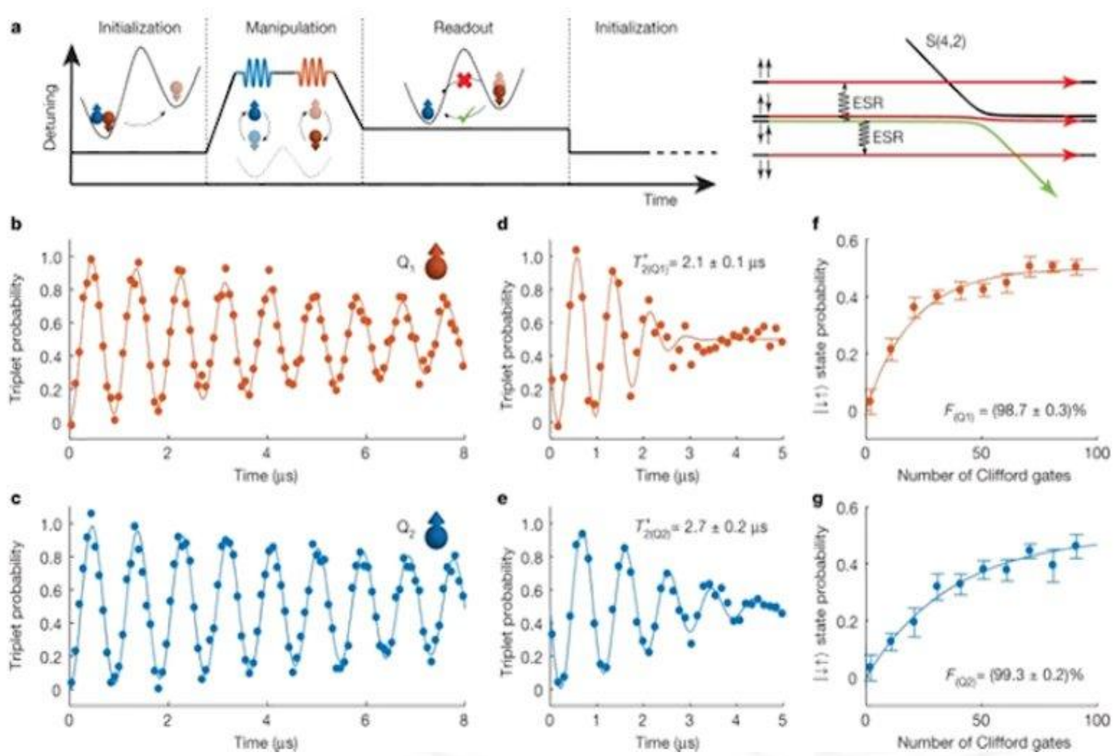
Universal quantum logic in hot silicon qubits

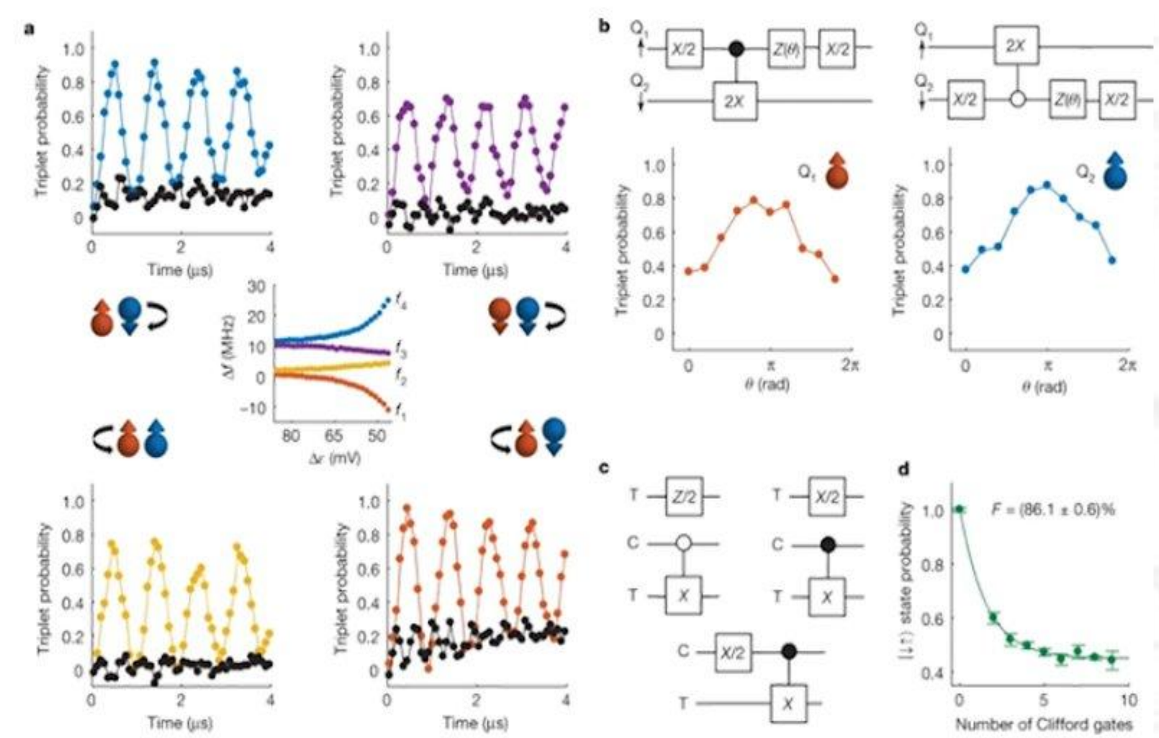
https://doi.org/10.1038/s41586-020-2170-7
Received: 22 October 2019
Accepted: 22 January 2020
Published online: 15 April 2020
Check for updates

L. Petit[1], H. G. J. Eenink[1], M. Russ[1], W. I. L. Lawrie[1], N. W. Hendrickx[1], S. G. J. Philips[1], J. S. Clarke[2], L. M. K. Vandersypen[1] & M. Veldhorst[1]✉

Quantum computation requires many qubits that can be coherently controlled and coupled to each other[1]. Qubits that are defined using lithographic techniques have been suggested to enable the development of scalable quantum systems because they

T = 1.1K

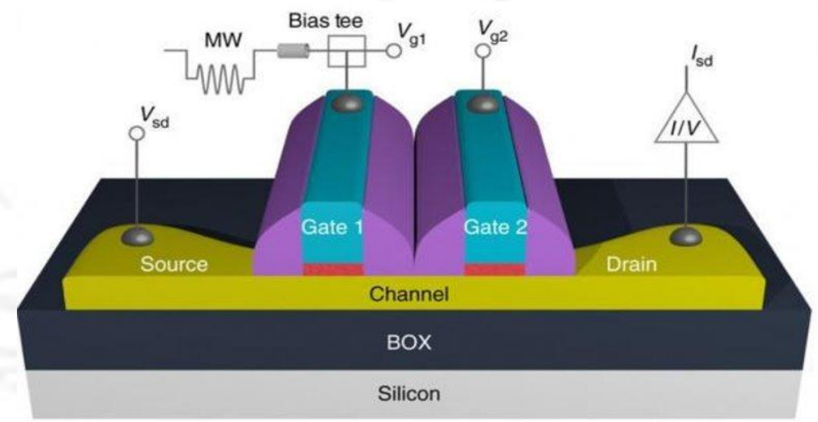


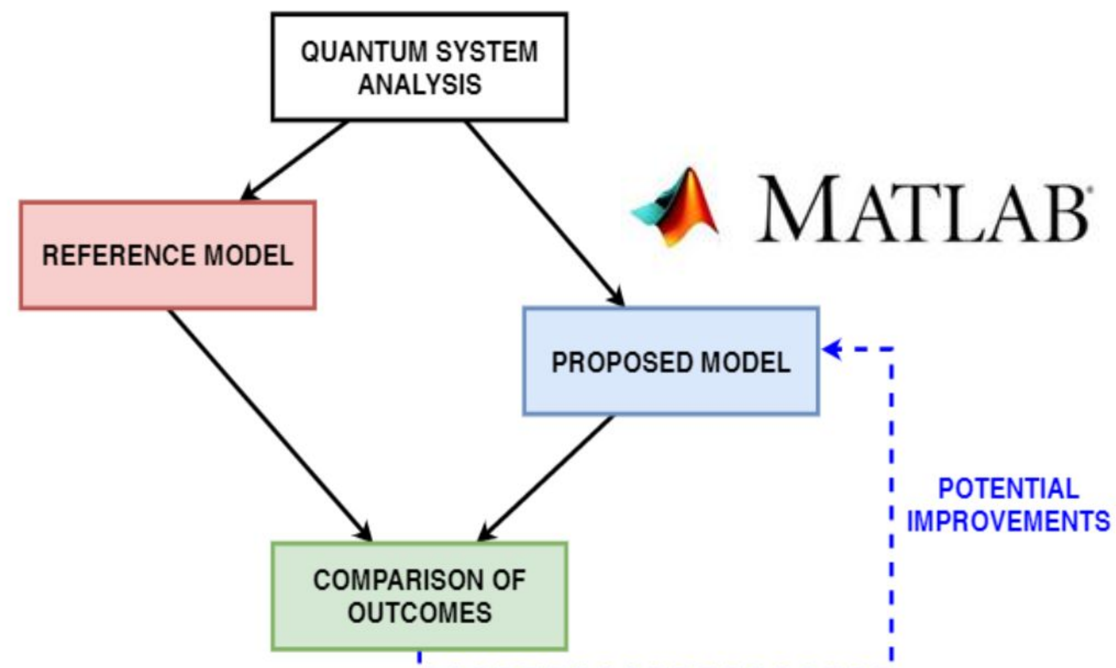


T.QC.1: QC with Silicon Quantum-Dots

Object: development of compact models for QC with silicon quantum-dots.

- Analysis of physical principles ruling the quantum device and the quantum system.
- Definition of an initial MATLAB compact model.
- Model validation based on the comparison with reference models and experimental data.
- Potential improvements of the compact model.
- Integration in the simulation infrastructure under development at VLSI Lab.

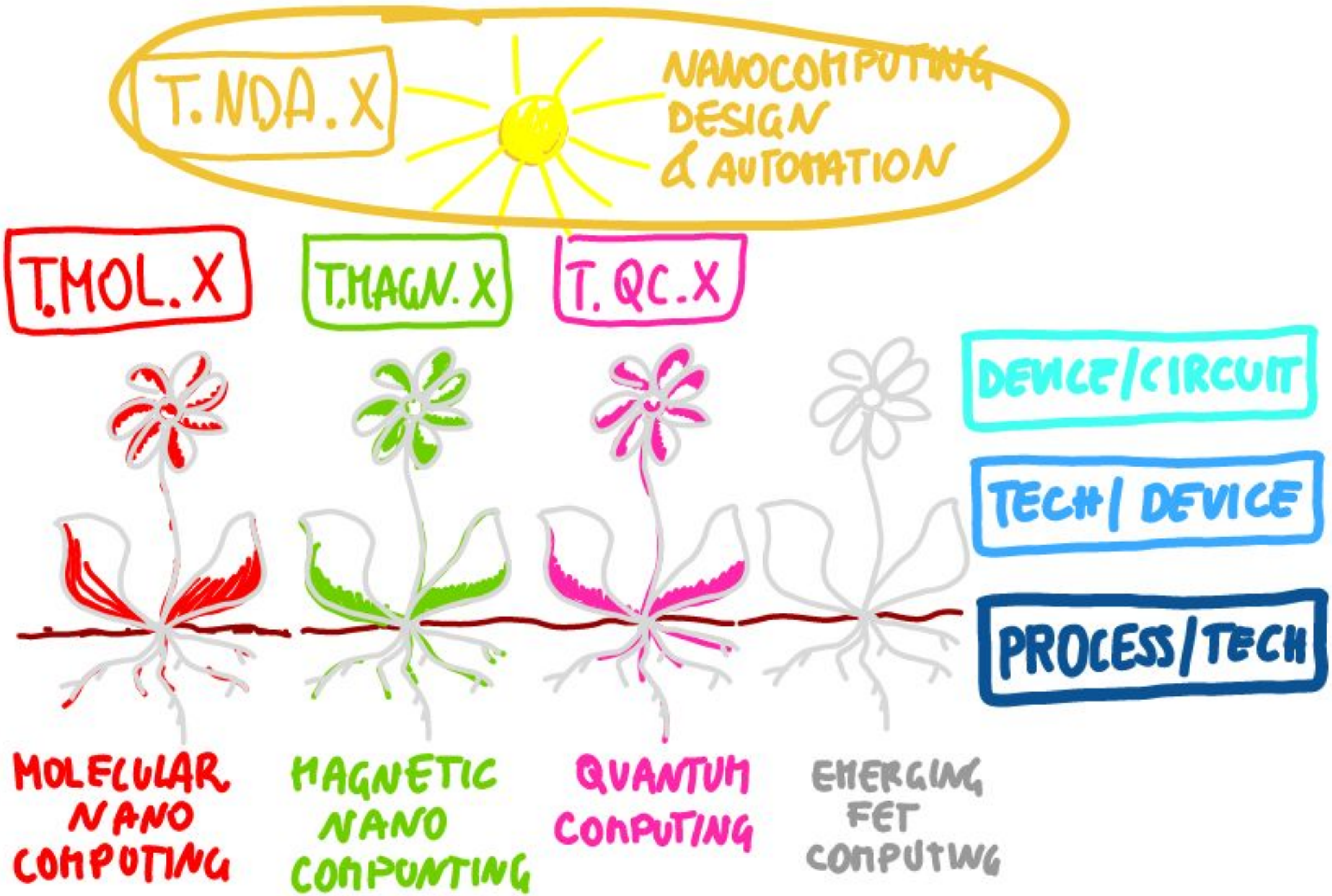




Analysis of physical principles → **Development of a compact model** → **Model validation and integration**

POLITECNICO DI TORINO

VLSI LAB NANOCOMPUTING



POLITECNICO DI TORINO

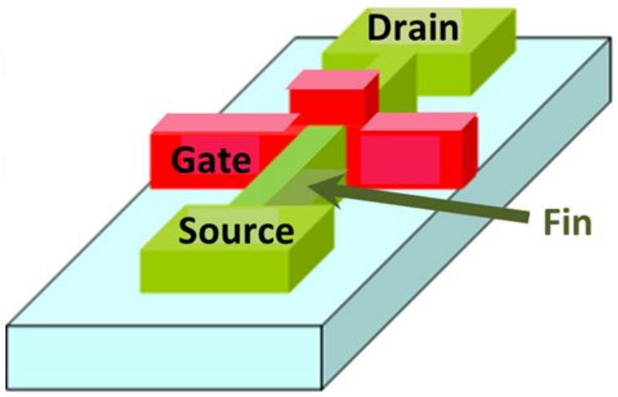
VLSI LAB NANOCOMPUTING

T.NDA.1 A new tool for fast process simulation of nanosystems

Object: Design a new tool for the simulation of technological processes

Current tools to perform process simulation are computationally expensive.

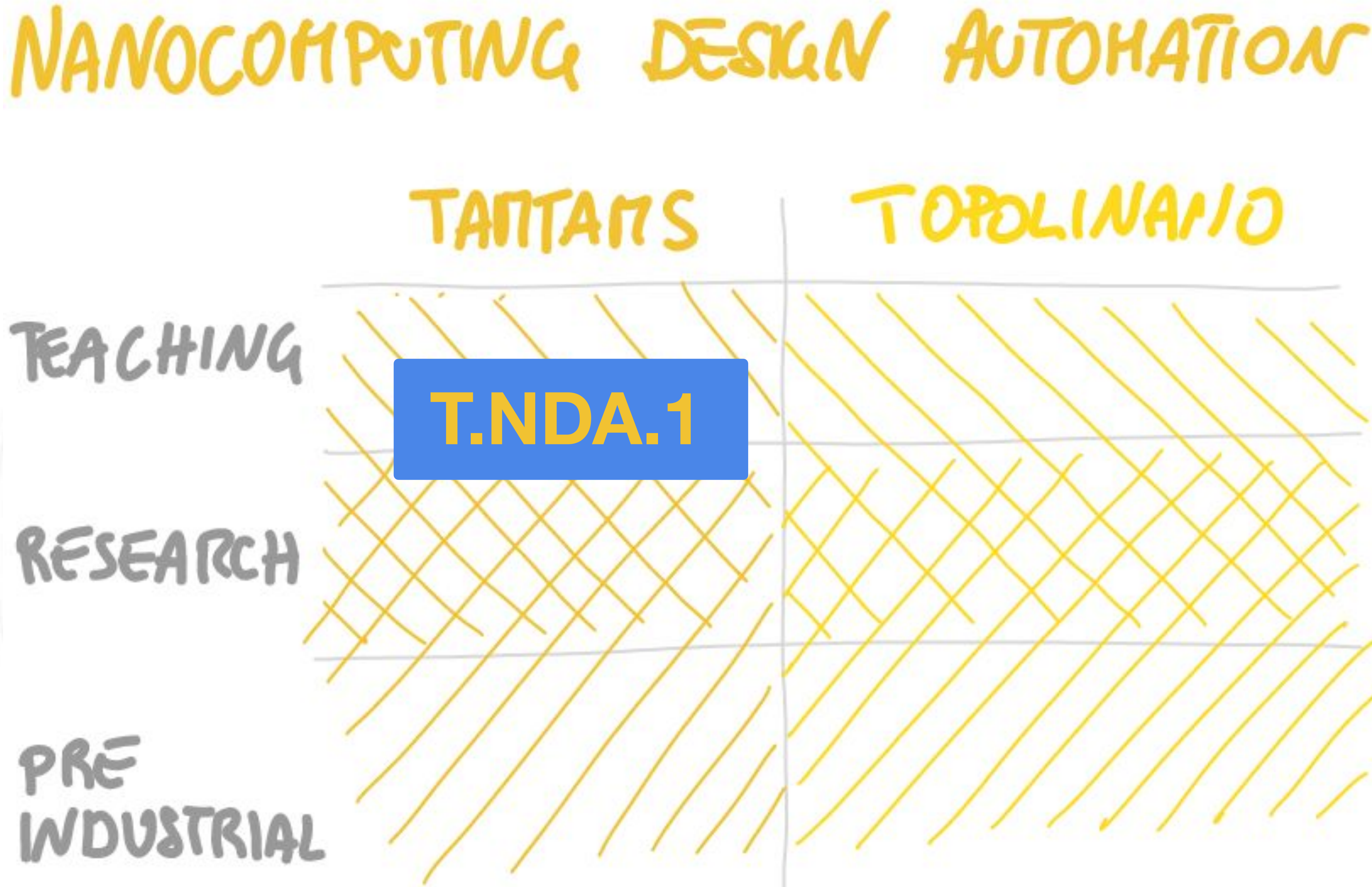
- Use a graphical library (TBD: blender, python, matlab) to develop a tool to draw 3D processes (etching, deposition, oxidation, …).
- Create functional simulation of technological processes (without any physical model) for nanosystems. E.g. Atomic Layer Deposition (ALD).
- Study physical models for processes, eventually validating them with literature or simulative results.
- Integrate physical models into the framework.
- Simulate the design-flow of some devices (e.g. FinFET).



POLITECNICO DI TORINO

NANOCOMPUTING

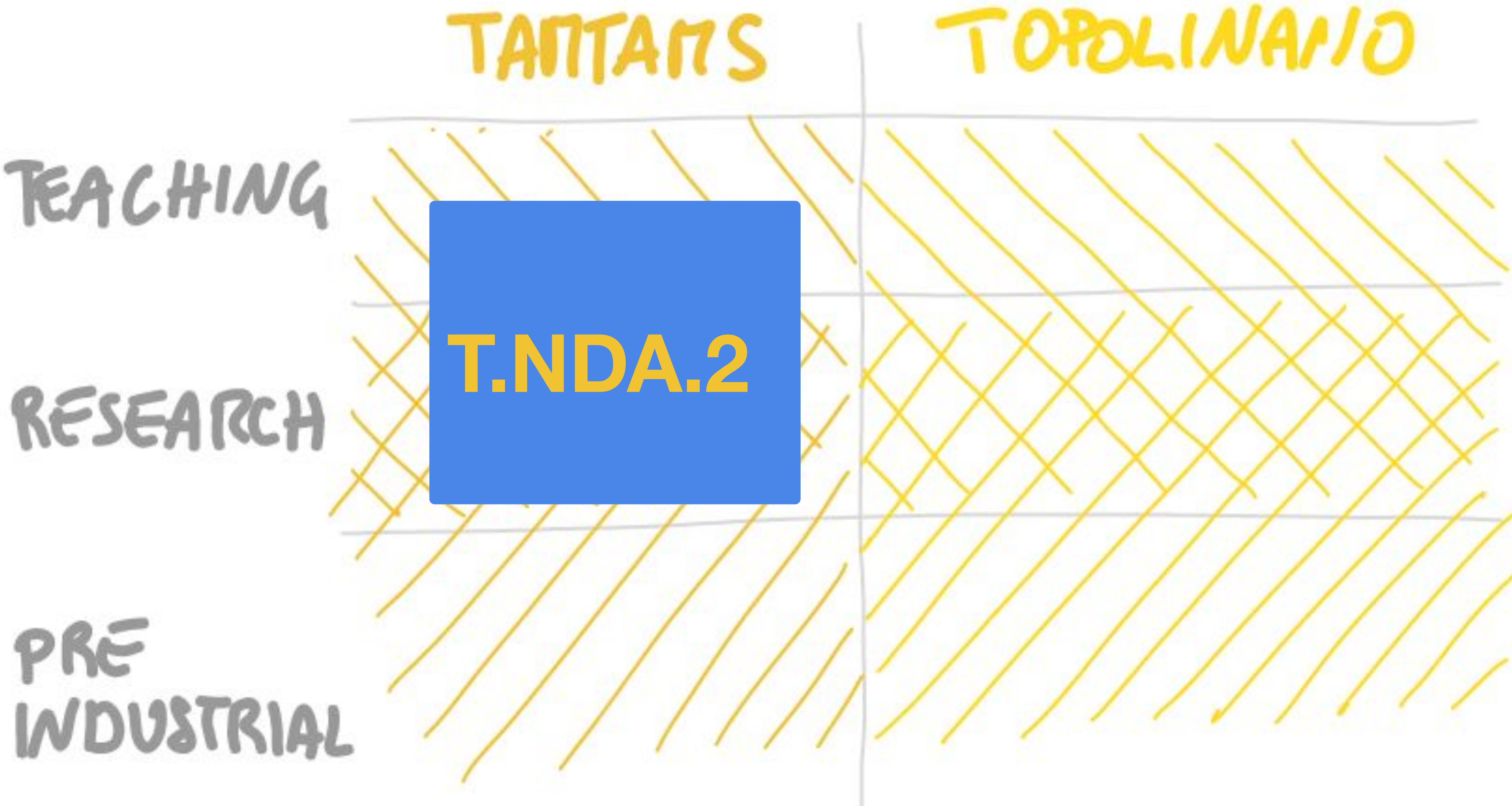
An inner MAP: technologies & applications



POLITECNICO DI TORINO

NANOCOMPUTING

NANOCOMPUTING DESIGN AUTOMATION



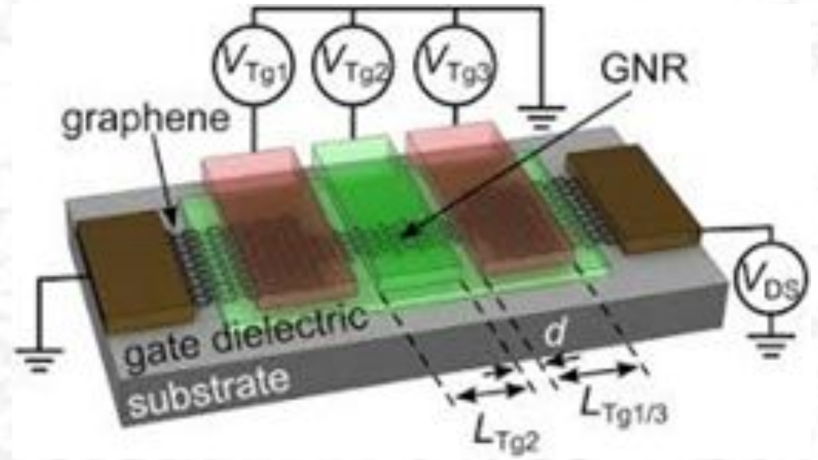
T.NDA.2 Device-level modeling of advanced transistors (1/2)

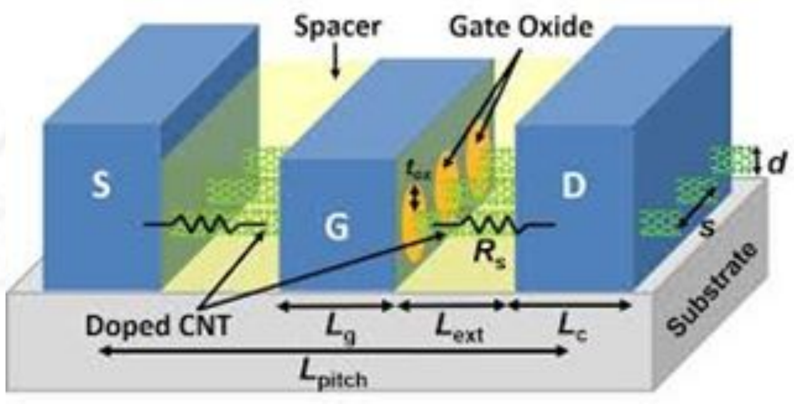
Object: Development of device-level suitable models for innovative technologies

- Choice of an innovative technology among: Semiconductor-based novel devices (FD-SOI, FinFET, GAA-FET, Si-NW-FET, …), T-FET, Graphene-FET, GNR-FET, CNT-FET, Molecular-FET, …
  (ONLY 1 TECH TO BE INVESTIGATED!)

  and study of suitable device-level modeling techniques for such a technology

- Device-level modeling with MATLAB





POLITECNICO DI TORINO

MATLAB

VLSI LAB NANOCOMPUTING

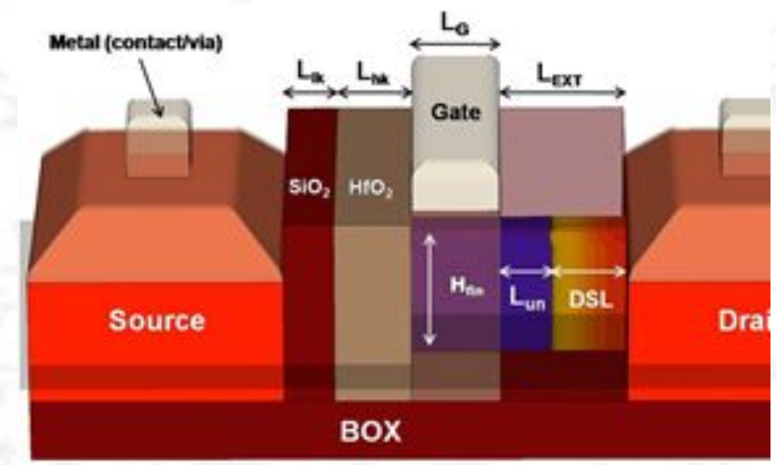
T.NDA.2 Device-level modeling of advanced transistors (2/2)

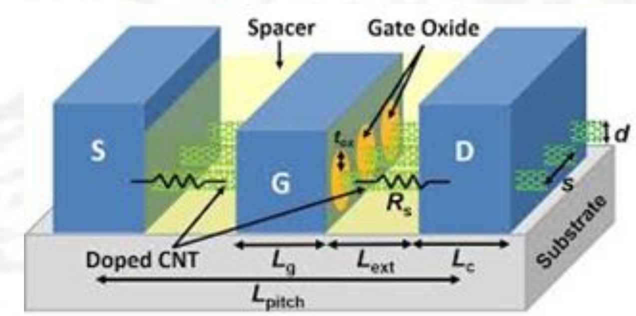
Object: Development of device-level suitable models for innovative technologies

- Validation of obtained results by means of physical simulators (Sentaurus-TCAD & QuantumATK)
- TAMTAMS framework for extraction, evaluation, conception of device figures of merit for performance evaluation

SYNOPSYS QUANTUMATK

Sentaurus TCAD SYNOPSYS

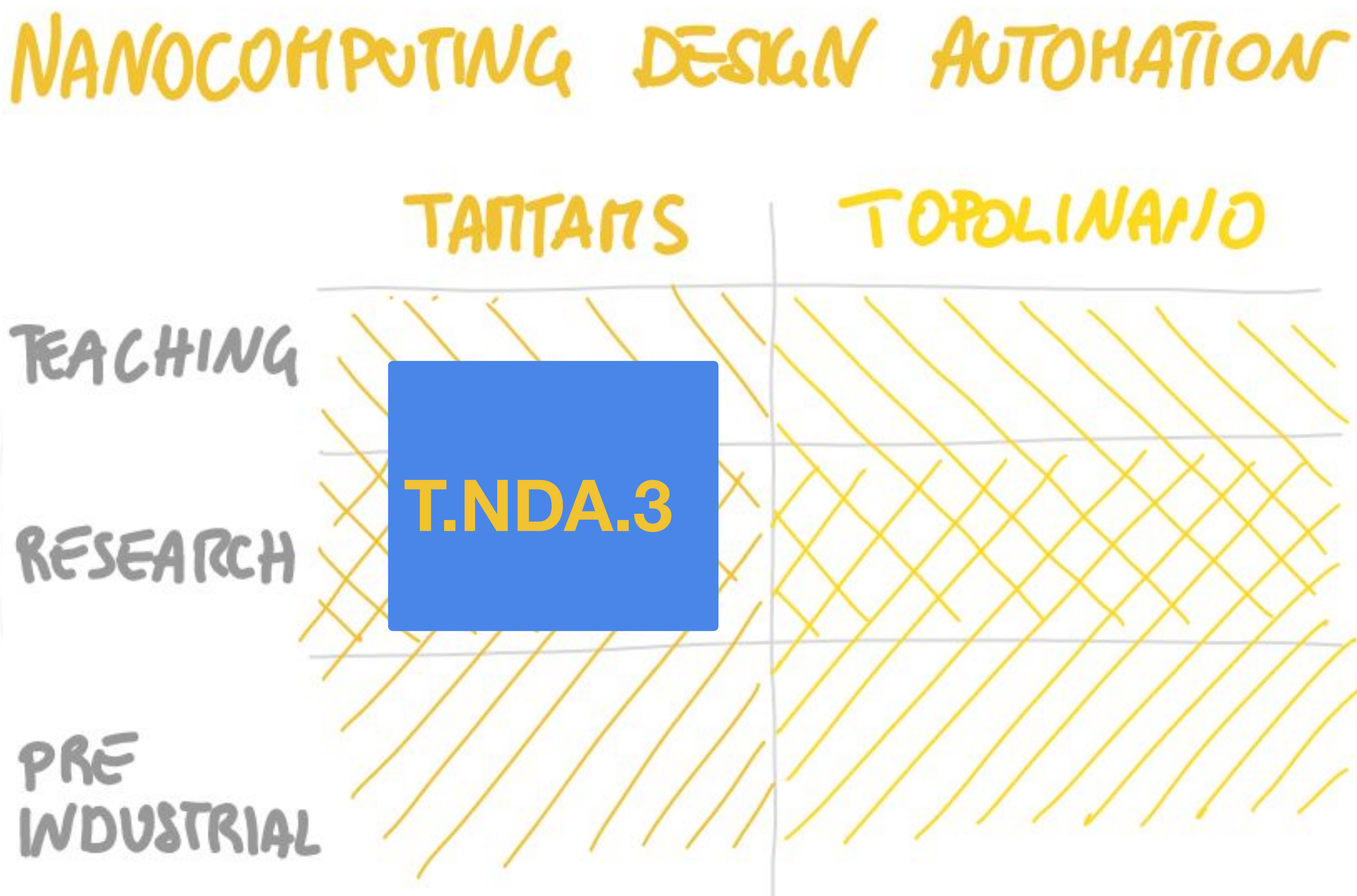




TAMTAMS

POLITECNICO DI TORINO

VLSI LAB NANOCOMPUTING

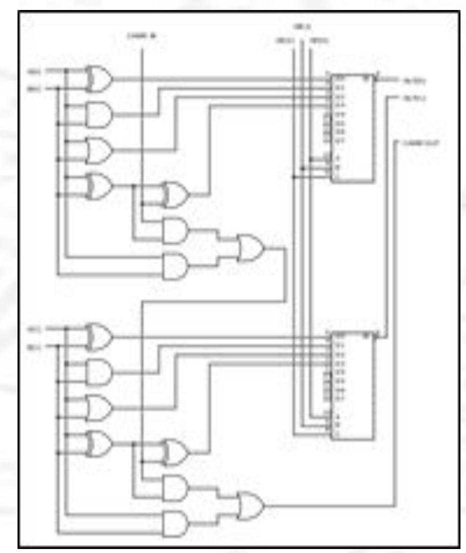

NANOCOMPUTING DESIGN AUTOMATION
TAMTAMS
TOPOLINANO
TEACHING
RESEARCH
PRE INDUSTRIAL

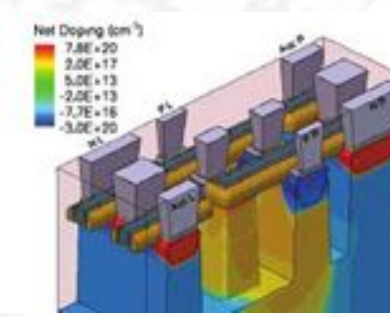
T.NDA.3

T.NDA.3 Technology impact on system performance (1/2)

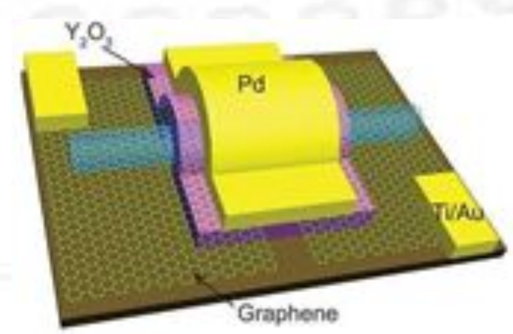
Object: Development of suitable models for evaluation of system-level performance

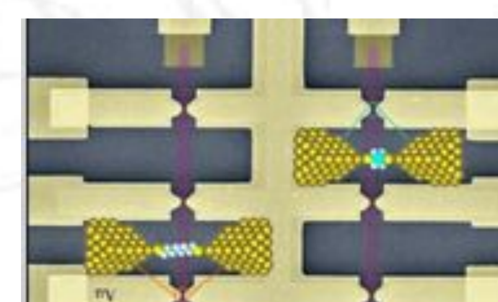
- Several (or even all) innovative technologies should be considered and then compared, they include: Semiconductor-based novel devices (FD-SOI, FinFET, GAA-FET, Si-NW-FET, …), T-FET, Graphene-FET, GNR-FET, CNT-FET, Molecular-FET, …





- Development of logic gates and digital systems with such new technologies





POLITECNICO DI TORINO

T.NDA.3 Technology impact on system performance (2/2)

Object: Development of suitable models for evaluation of system-level performance

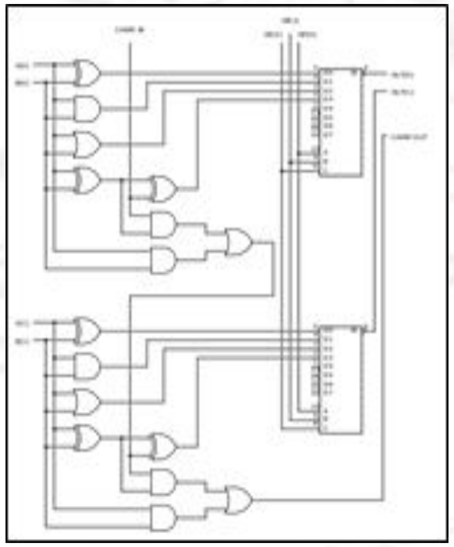
- Development of system-level models for evaluation of performance
- Validation of developed models with circuit implementations (Synopsys & Virtuoso)
- Complex systems performance evaluation and comparison among different technological choices with the help of TAMTAMS framework

MATLAB

SYNOPSYS QUANTUMATK

Sentaurus TCAD SYNOPSYS

Custom IC Design Virtuoso cādence

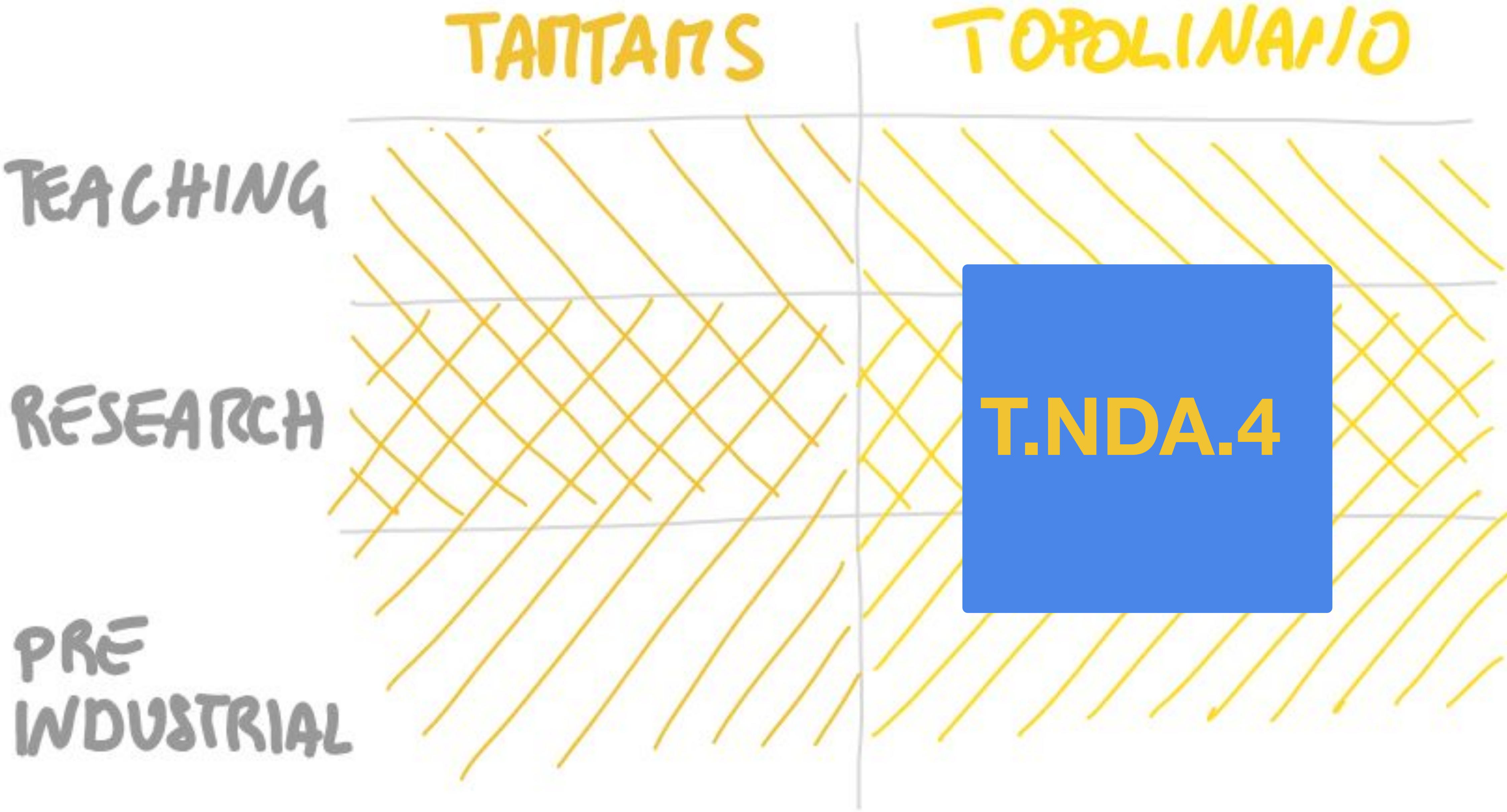


TAMTAMS

POLITECNICO DI TORINO

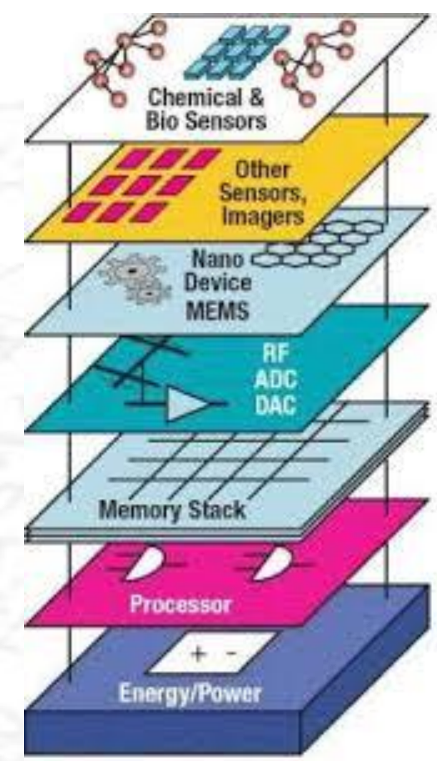
VLSI LAB NANOCOMPUTING

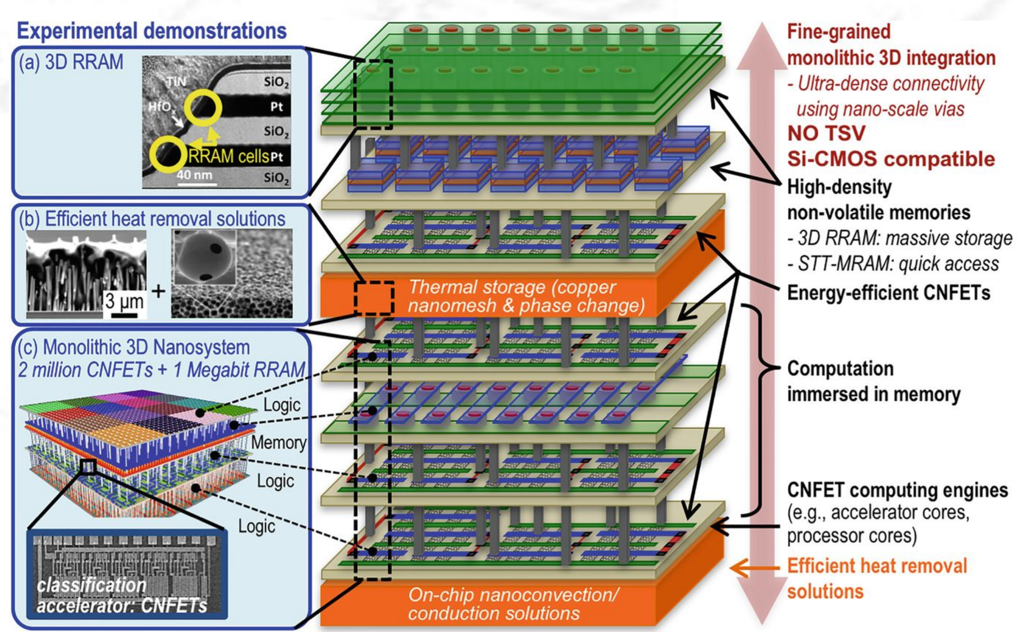
NANOCOMPUTING DESIGN AUTOMATION



T.NDA.4 Hybrid CMOS/Emerging Devices Design Flow

- Study and exploration of existing hybrid design flow (identify advantages and limitations)
- Develop a methodology for hybrid simulations of CMOS and emerging devices (e.g. magnetic circuits) taking into account the physics of the technology
- Apply the hybrid methodology to some case study technologies (e.g. MTJ/Skyrmions/pNML CMOS)





POLITECNICO DI TORINO

VLSI LAB NANOCOMPUTING

Questions?

www.vlsilab.polito.it

The theses presented here are ready now and available in the next few months. However other related or prosecutions will be available later.