QUARMEN

QUAntum Research Master Education Network

Erasmus Mundus Joint Master Degree (EMJMD)

Rinaldo Trotta

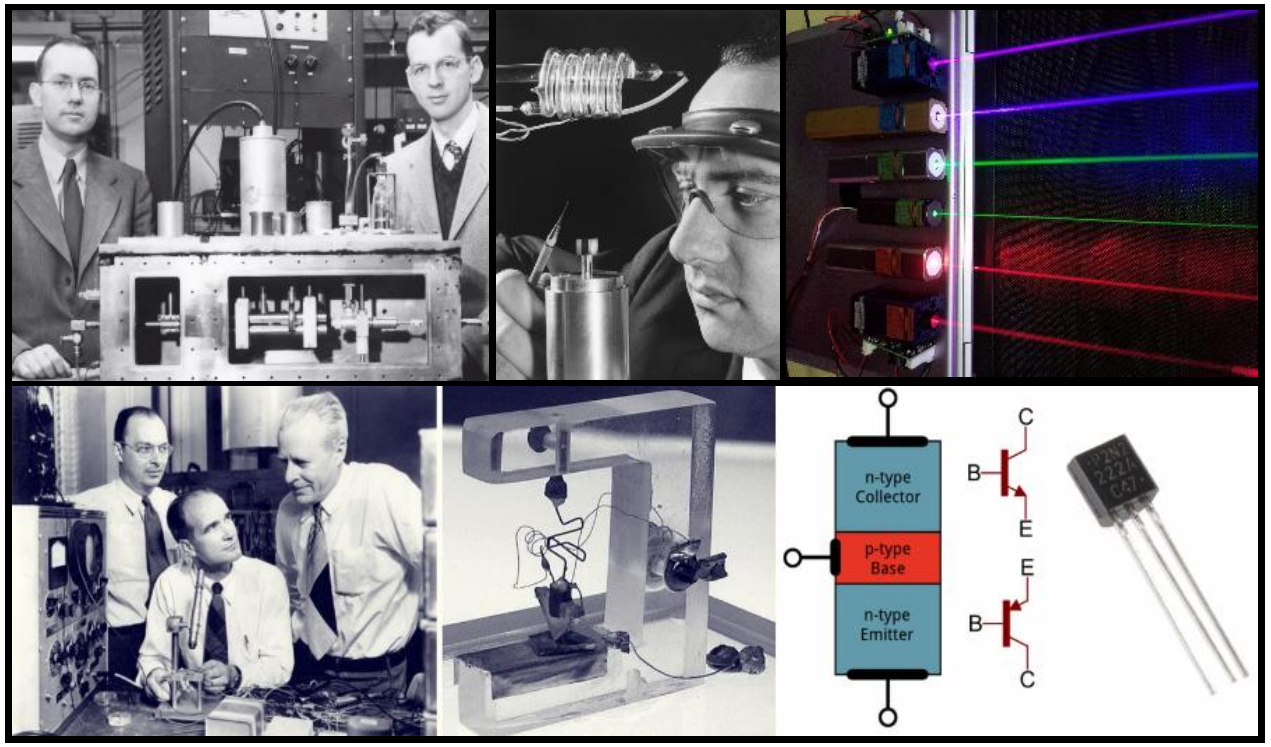
DIPARTIMENTO DI FISICA
SAPIENZA
UNIVERSITÀ DI ROMA

Erasmus Mundus

Quantum Technologies

Lasers, transistors,... we are already surrounded by quantum technologies!

(Quantum) behavior of electrons in solids and stimulated emission of coherent radiation

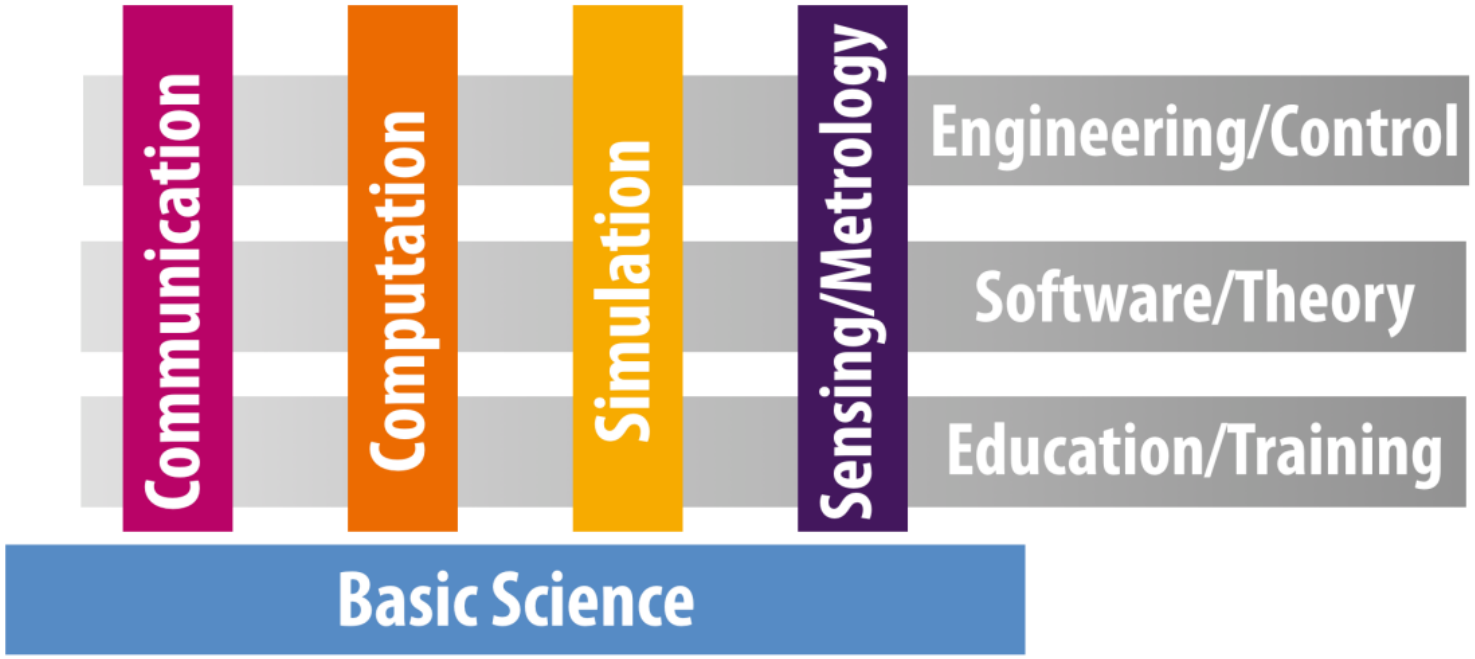


QUANTUM 1.0
(or the first quantum revolution)

Quantum Technologies

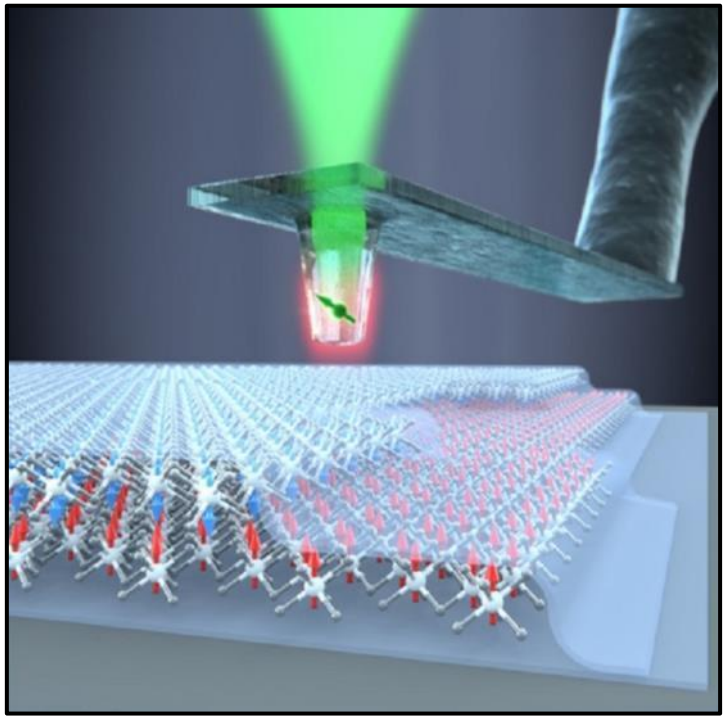
?

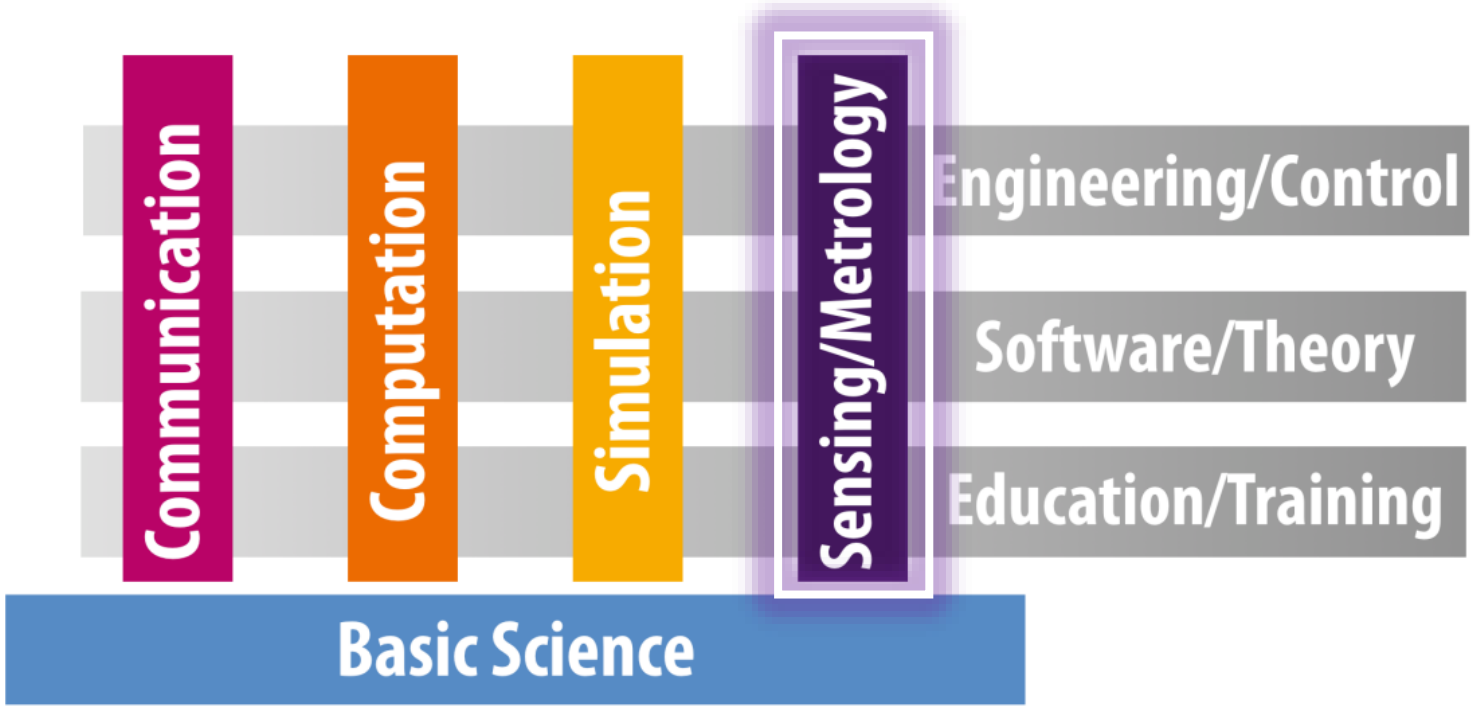
… we would like to exploit subtle quantum effects, such as superposition and entanglement



QUANTUM 2.0
(or the second quantum revolution)

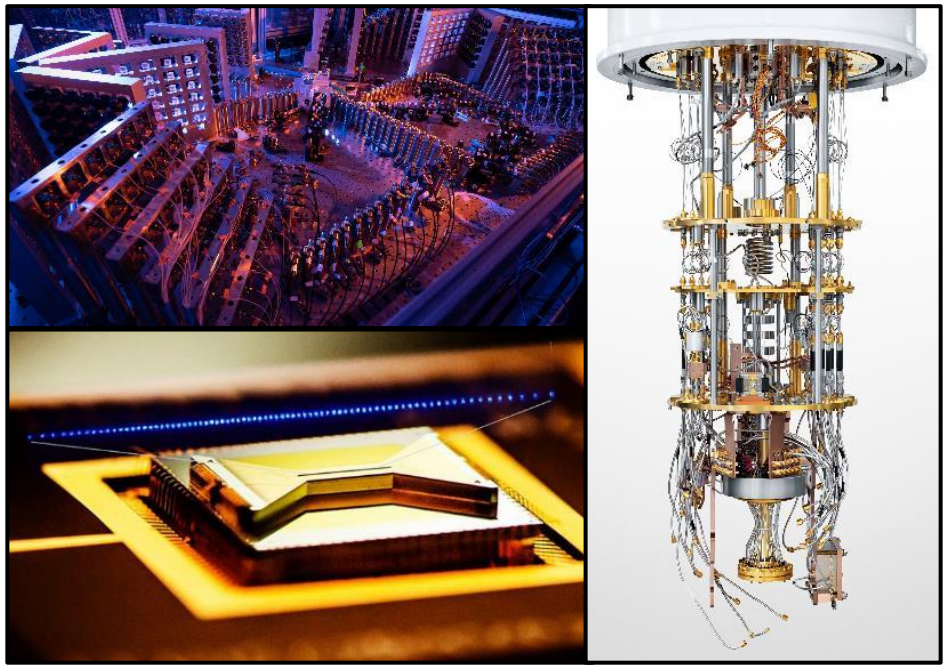
Quantum Technologies

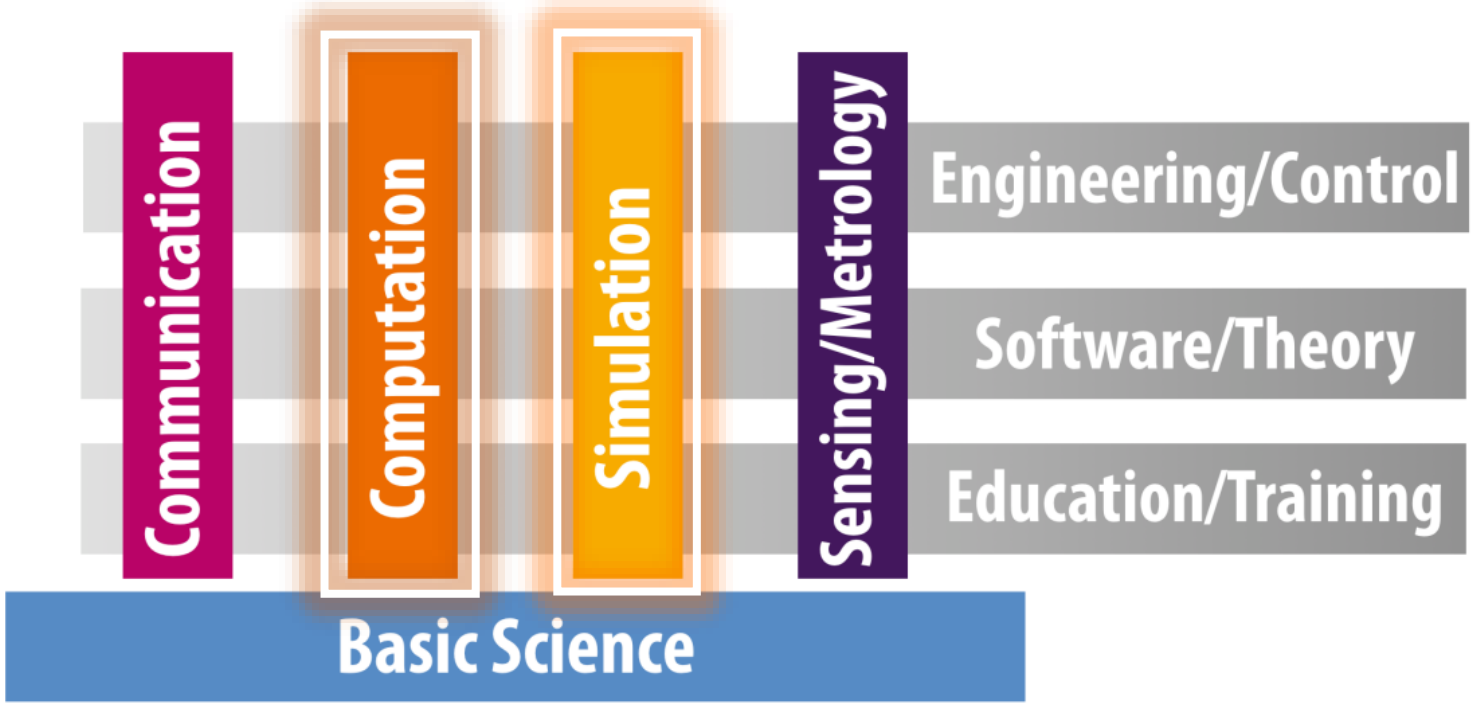




Development of sensors that can image magnetic and electric fields with high sensitivity and nanoscale resolution

Quantum Technologies

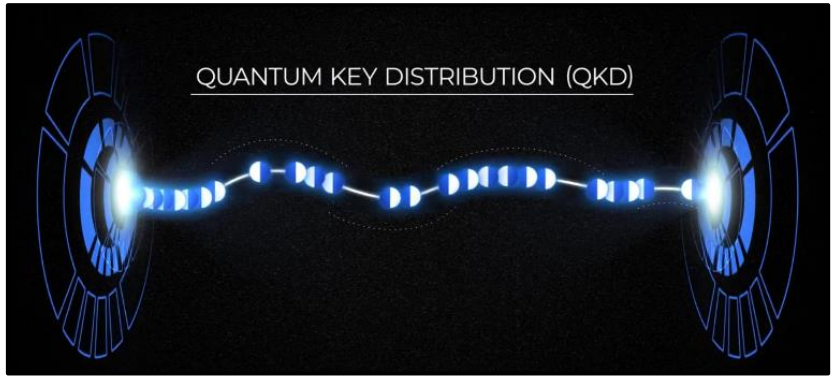


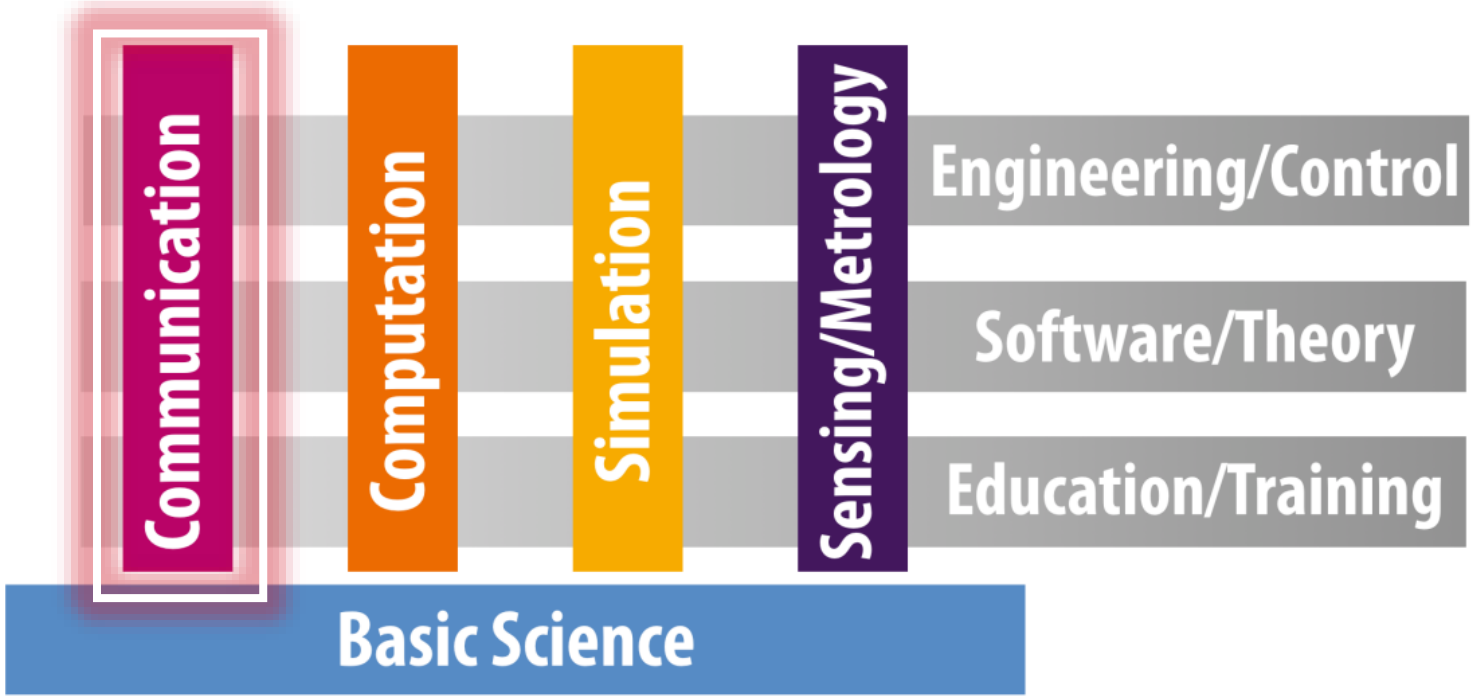


Development of quantum algorithms acting on quantum bits → quantum computers that are able to perform certain tasks much faster than any existing supercomputer

H.-S. Zhong et al., *Phys. Rev. Lett.* **127**, 180502 (2021) / Rigetti computing / IonQ

Quantum Technologies

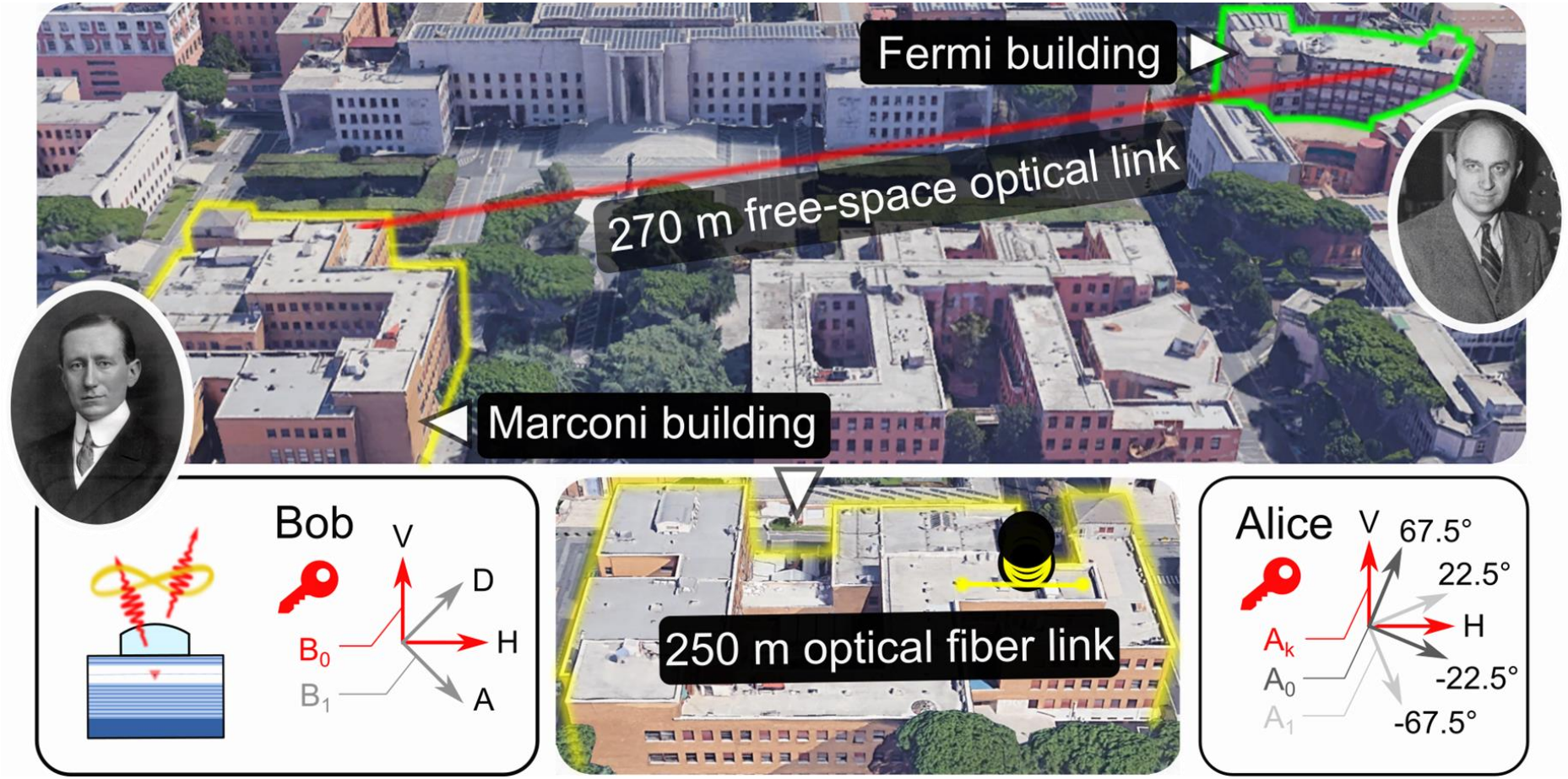




Development of secure communication systems using single and entangled photons

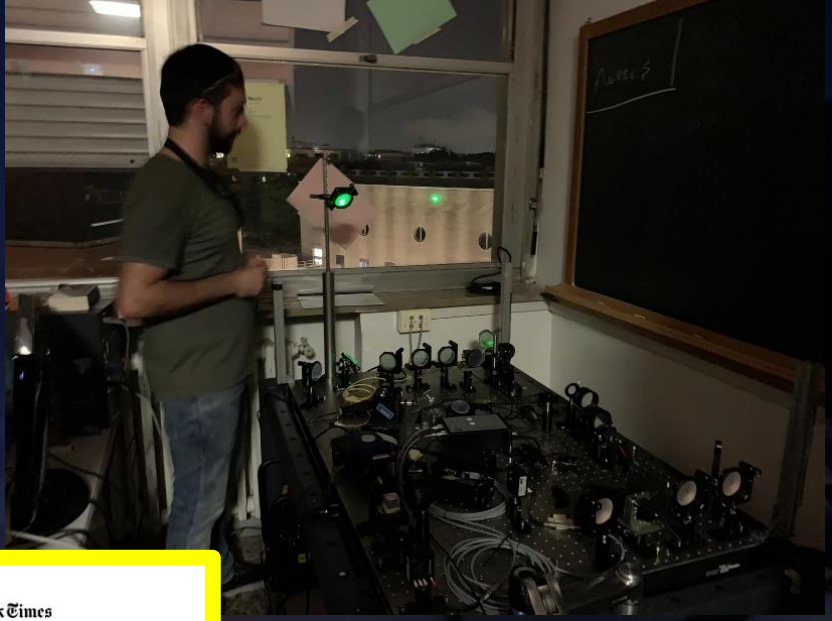
Commercial rack-mountable QKD systems

Quantum Technologies

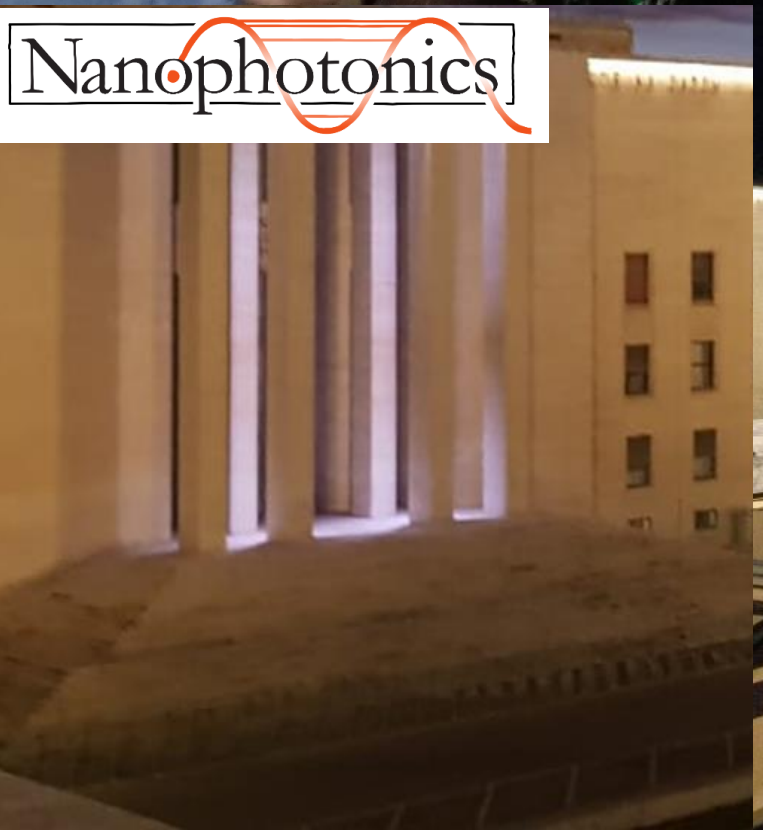


Nanophotonics

F. Basso Basset, M. Valeri,…, F. Sciarrino, and R. Trotta, Science Advances **7**, eabe6379 (2021)



Nanophotonics



The New York Times

ROME DISPATCH

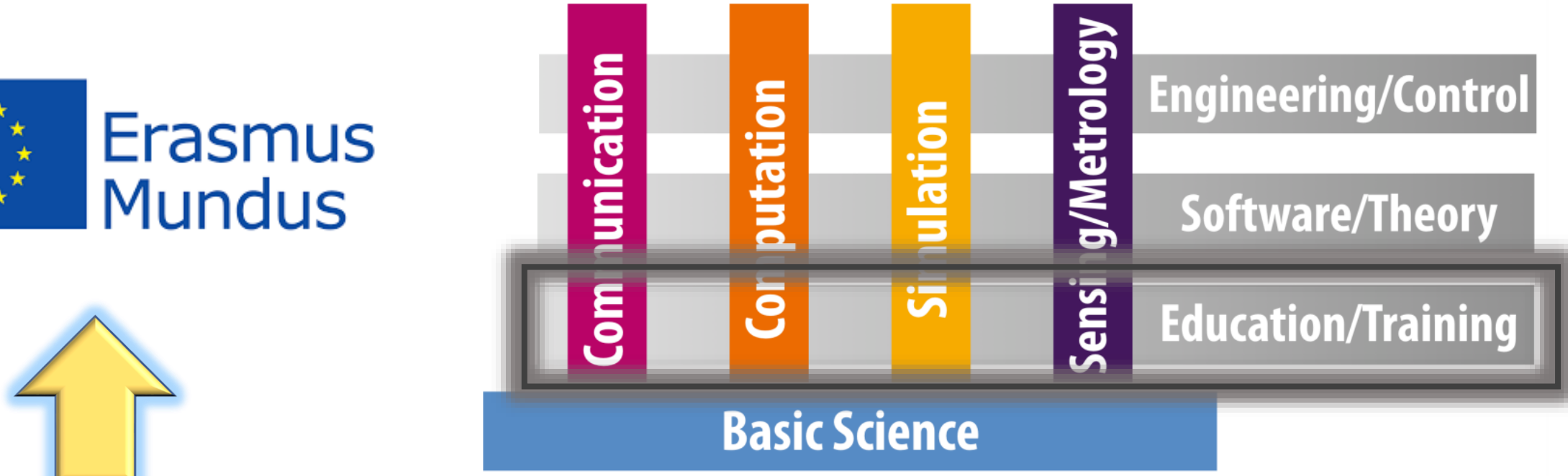
When in Rome, Sea Gulls Do as They Please

QUROPE

FET Open
QUROPE

Quantum Technologies

Erasmus Mundus



Strong need of highly qualified and trained scientists to be recruited at the Master level but **there are not enough young experts, and their educational background is not optimal**

QUARMEN

Preparing a new generation of experts for the second Quantum revolution with a two-year international Master program in Physics based on:

- training on concepts and technology for quantum devices and information
- international mobility among up to four different countries and research institutions
- possibility of preparing a Master Thesis in top level research centers
- offering and encouraging internships in quantum technology companies and start-ups
- promoting and training in entrepreneurial and project management skills

→ QUARMEN will provide an **advanced and internationally competitive training**, putting the students in the best conditions either to pursue a **Ph.D. in quantum science and technology**, or to enter the lively job market of **high-tech companies** in the field

QUARMEN

SCHOLARSHIPS

- **Erasmus+**: Erasmus Mundus (about 20 scholarships per year): 1,400€/month + fee waiving
- **Fee waiving scholarships** (about 10 scholarships per year)
- **Paris-Saclay scholarships** (about 5 scholarships per year): 20,000 € for 2 years + reimbursement of travel costs

ADMISSION

- Applicants should have or should be in process to get a Bachelor degree in physics or related topics + English skills
- Applications on Paris-Saclay University's website (opening February 1st, 2022):
- **Applications must be submitted online** before **April 3rd, 2022** on the website:

https://inception.universite-paris-saclay.fr/en/

For more information and questions, please do not hesitate to ask questions at:

rinaldo.trotta@uniroma1.it

master.quarmen@universite-paris-saclay.fr

ACADEMIC PROGRAM

Year 1 (60 ECTS)

Semester 1 (30 ECTS)

Rome – La Sapienza University

Condensed matter physics (6 ECTS)
Physics Laboratory 1 (6 ECTS)
Introduction to quantum field theory (6 ECTS)
Computing methods for physics (6 ECTS)
Non-linear and quantum optics (6 ECTS)
+ Language course

Winter School

Semester 2 (30 ECTS)

Paris-Saclay University

Quantum effects at the macroscale (6 ECTS)
Advanced mathematics for physics (3 ECTS)
Statistical Physics (3 ECTS)
Functional Quantum materials (3 ECTS)
Quantum Hardware (3 ECTS)
Language course (3 ECTS)
Internship (6 ECTS)
Option (3 ECTS): Research project
Machine Learning for Quantum Tech

University of Porto

Introduction to quantum information (6 ECTS)
Quantum materials (6 ECTS)
High performance computing (3 ECTS)
Computational complexity (6 ECTS)
Language course (3 ECTS)
Options (6 ECTS): Sensing and signal analysis
Quantum and statistical field theory
Advanced computer architectures
Internship

Year 2 (60 ECTS)

Summer School (5 ECTS)

Semester 3 (30 ECTS)

Paris-Saclay University

Quantum Optics - Quantum Materials – Nanoscience

Common courses (15 ECTS)
Physics of Quantum Information: qubits, entanglement (3)
Fundamentals of micro and nanofabrication (3)
Lab project (optics/ nanofabrication / analysis) (6)
Introduction to 2nd quantization: from q. optics to solids (3)

options: at least 15 ECTS, among (3 ECTS each):
Advanced micro and nanofabrication; Integrated optics and nanophotonics; Solid state devices ; Quantum communication; Quantum sensing; Quantum transport; Physics experiments in Quantum Technologies; Topology; Quantum dynamics of many-body systems; Nano-medicine and nano-toxicology; Biophotonics

University of Toronto

Quantum cryptography - Quantum control - Cold atoms

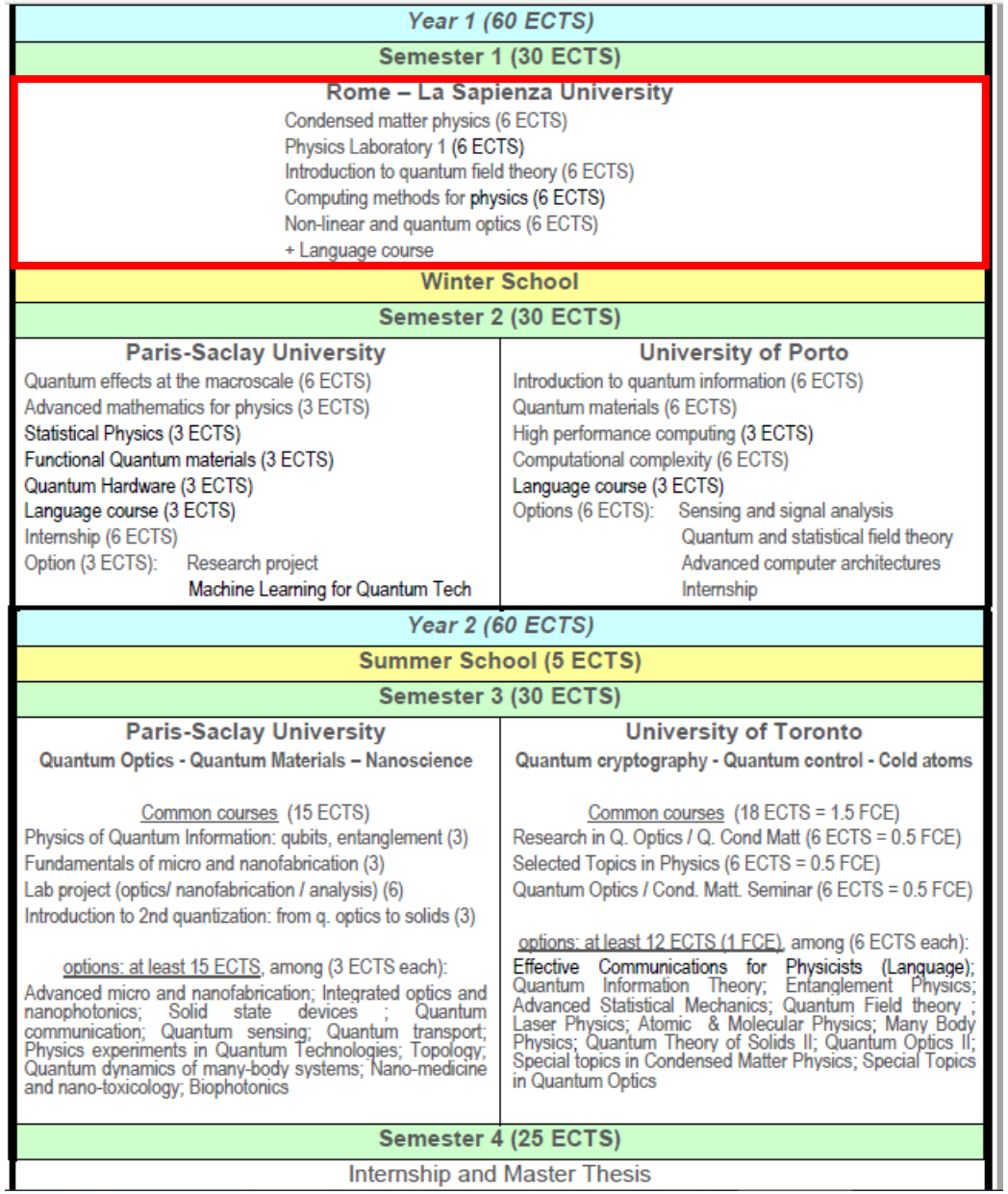
Common courses (18 ECTS = 1.5 FCE)
Research in Q. Optics / Q. Cond Matt (6 ECTS = 0.5 FCE)
Selected Topics in Physics (6 ECTS = 0.5 FCE)
Quantum Optics / Cond. Matt. Seminar (6 ECTS = 0.5 FCE)

options: at least 12 ECTS (1 FCE), among (6 ECTS each):
Effective Communications for Physicists (Language); Quantum Information Theory; Entanglement Physics; Advanced Statistical Mechanics; Quantum Field theory ; Laser Physics; Atomic & Molecular Physics; Many Body Physics; Quantum Theory of Solids II; Quantum Optics II; Special topics in Condensed Matter Physics; Special Topics in Quantum Optics

Semester 4 (25 ECTS)

Internship and Master Thesis

ACADEMIC PROGRAM



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Quantum Hardware (3 ECTS)	Language course (3 ECTS)
Language course (3 ECTS)	Options (6 ECTS): Sensing and signal analysis
Internship (6 ECTS)	Quantum and statistical field theory
Option (3 ECTS): Research project	Advanced computer architectures
Machine Learning for Quantum Tech	Internship

Year 2 (60 ECTS)

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Paris-Saclay University	University of Toronto
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Semester 4 (25 ECTS)

Internship and Master Thesis

Fully connected to our Curriculum
Condensed Matter Physics: Theory and Experiment
(Photonics and Quantum Technologies)

- Condensed Matter Physics (mandatory - 6 ECTS)
- Physics Lab I (mandatory – 6 ECTS)
- Introduction to quantum field theory (mandatory – 6 ECTS)
- Computing Methods for Physics (mandatory and INF – 6 ECTS)
- Nonlinear and Quantum Optics (6 ECTS)

+ language course (English or Italian)

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Language course (3 ECTS)	Options (6 ECTS): Sensing and signal analysis
Internship (6 ECTS)	Quantum and statistical field theory
Option (3 ECTS): Research project	Advanced computer architectures
Machine Learning for Quantum Tech	Internship

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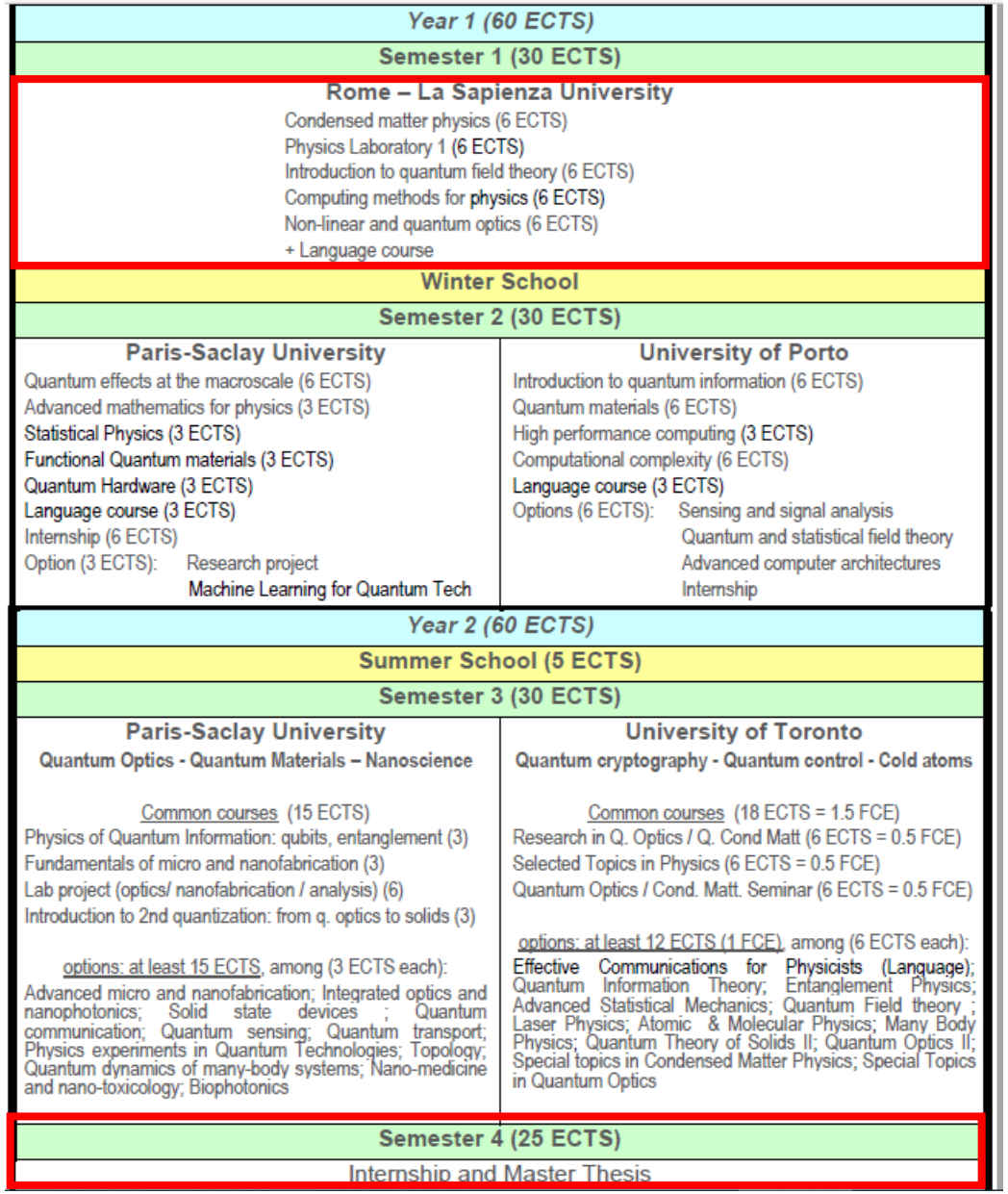

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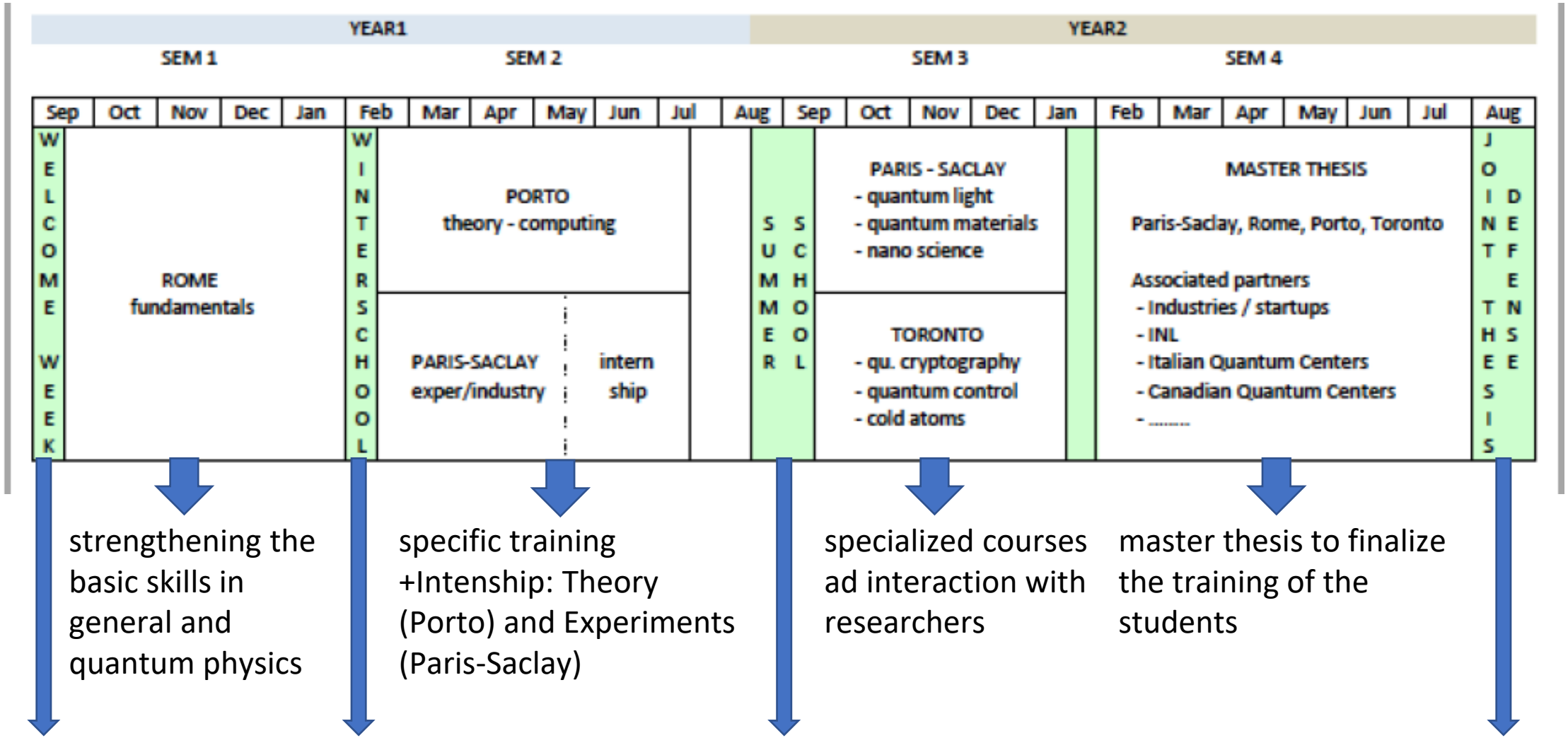
Master Thesis can be performed in one of the groups of our Department

Associated Partners

Non-academic partners	*Higher education institutions*	*Research organisation*
EU Dynamic optics *(Italy) – company* Thales Alenia Space *(Italy) - company* Sphere Photonics *(Portugal) - company* EDF *(France) – company* Orange *(France) – company* Pasqal *(France) - startup* Quandela *(France) - startup* Qubit *(France) - startup* **North America** Xanadu *(Canada) - company* Entangled Network *(Canada) - startup* Bridge Technologies *(Canada) - startup* Agnostiq *(Canada) - startup*	**EU** Technical University of Denmark *(Denmark)* University of Warsaw *(Poland)* Institut Polytechnique de Paris *(France)* **North America** City College of the City University of New York *(USA)*	**EU** Institute for Systems and Computer Engineering, Technology and Science INESC TEC *(Portugal)* International Iberian Nanotechnology Laboratory INL *(Portugal)* Trieste Institute for Theoretical Quantum Technologies – SISSA *(Italy)* Munich Center for Quantum Science and Technology MCQST *(Germany)* Institute of Photonic Sciences ICFO *(Spain)*

- Contribution to the educational program
- Visit of the research and/or production site
- Offering internships for master thesis
- Discussions and consulting on the development and implementation of the training program

Mobility of Students



Thank you for your attention