QUANTUM TECHNOLOGIES: PREPARING THE NEW FLAGSHIP

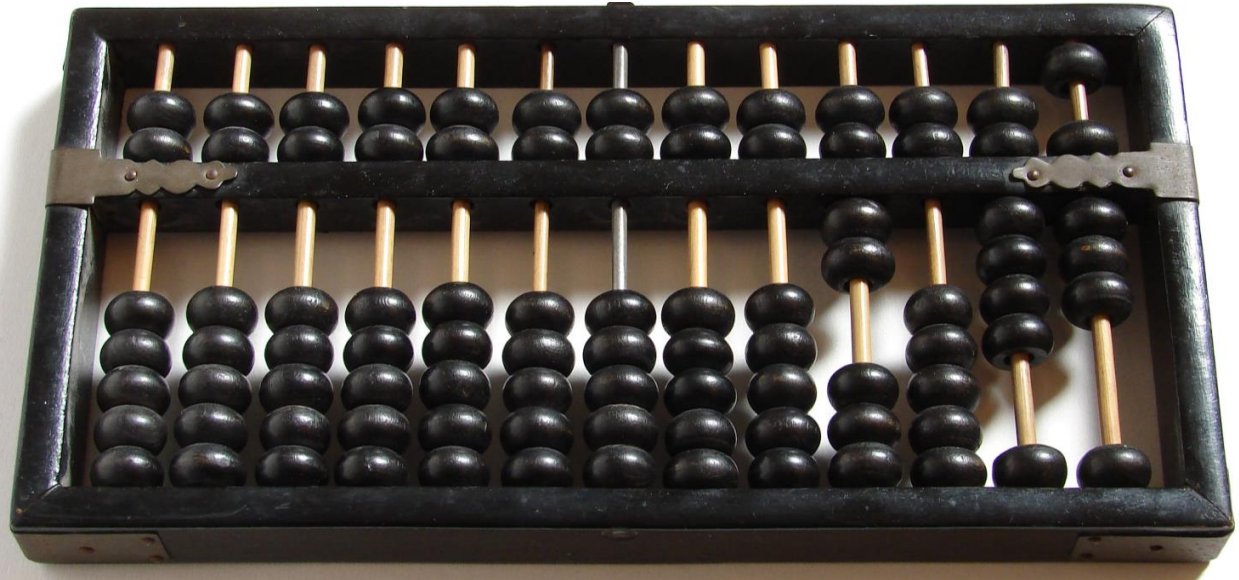
Prof. Dr. Jürgen Mlynek

Chairman of the High-Level Steering Committee
European Commission Quantum Technology Flagship Project

5th Meeting of the FET Flagships Board of Funders
23 January 2017

„Quantum information is a radical departure in information technology,
more fundamentally different from current technology
than the digital computer is from the abacus.“

W. D. Phillips
Nobel laureate 1997



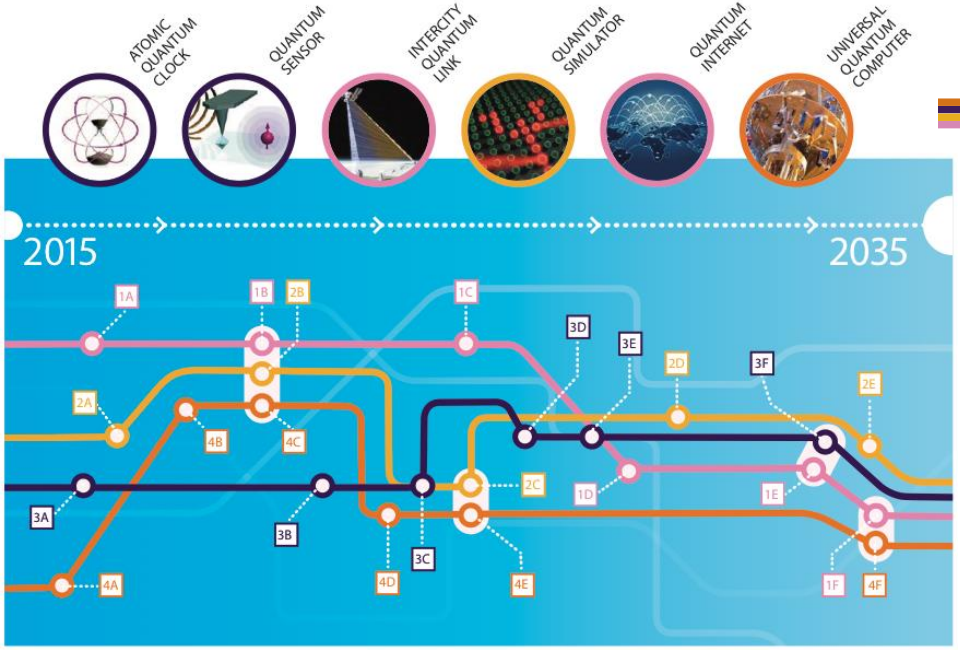
Quantum Technology

Europe‘s position in the world

- Europe is the global leader in QT, roughly half of the world‘s publications in the field come from EU-based groups
- EU Roadmap already in place: constant progress, milestones reached, gaps and challenges identified
- Europe‘s competitors around the world (USA, China, Japan, Russia, Singapore, Australia) are developing their own quantum research programs
- overall many branches of QT have gone past the proof-of-principle phase, but further progress can only be achieved through the leap in resources and the long-term commitments coming with it
- strong QT Community: Quantum Manifesto with over 3500 supporters

Quantum Manifesto

- an initiative of the European Quantum Community
- published in May 2016, supported by over 3500 scientists, research institutions and companies
- main goal: aid the selection of QT as the new European flagship project



	1. Communication	2. Simulators	3. Sensors	4. Computers
0 – 5 years	A Core technology of quantum repeaters B Secure point-to-point quantum links	A Simulator of motion of electrons in materials B New algorithms for quantum simulators and networks	A Quantum sensors for niche applications (incl. gravity and magnetic sensors for health care, geosurvey and security) B More precise atomic clocks for synchronisation of future smart networks, incl. energy grids	A Operation of a logical qubit protected by error correction or topologically B New algorithms for quantum computers C Small quantum processor executing technologically relevant algorithms
5 – 10 years	C Quantum networks between distant cities D Quantum credit cards	C Development and design of new complex materials D Versatile simulator of quantum magnetism and electricity	C Quantum sensors for larger volume applications including automotive, construction D Handheld quantum navigation devices	D Solving chemistry and materials science problems with special purpose quantum computer > 100 physical qubit
> 10 years	E Quantum repeaters with cryptography and eavesdropping detection F Secure Europe-wide internet merging quantum and classical communication	E Simulators of quantum dynamics and chemical reaction mechanisms to support drug design	E Gravity imaging devices based on gravity sensors F Integrate quantum sensors with consumer applications including mobile devices	E Integration of quantum circuit and cryogenic classical control hardware F General purpose quantum computers exceed computational power of classical computers

2015

ATOMIC QUANTUM CLOCK

QUANTUM SENSOR

INTERCITY QUANTUM LINK

QUANTUM SIMULATOR

QUANTUM INTERNET

UNIVERSAL QUANTUM COMPUTER

2035

1. Communication

0 – 5 years

A Core technology of quantum repeaters

B Secure point-to-point quantum links

5 – 10 years

C Quantum networks between distant cities

D Quantum credit cards

> 10 years

E Quantum repeaters with cryptography and eavesdropping detection

F Secure Europe-wide internet merging quantum and classical communication

2. Simulators

0 – 5 years

A Simulator of motion of electrons in materials

B New algorithms for quantum simulators and networks

5 – 10 years

C Development and design of new complex materials

D Versatile simulator of quantum magnetism and electricity

> 10 years

E Simulators of quantum dynamics and chemical reaction mechanisms to support drug design

2015

ATOMIC QUANTUM CLOCK

QUANTUM SENSOR

INTERCITY QUANTUM LINK

QUANTUM SIMULATOR

QUANTUM INTERNET

UNIVERSAL QUANTUM COMPUTER

2035

3. Sensors

A Quantum sensors for niche applications (incl. gravity and magnetic sensors for health care, geosurvey and security)

B More precise atomic clocks for synchronisation of future smart networks, incl. energy grids

C Quantum sensors for larger volume applications including automotive, construction

D Handheld quantum navigation devices

E Gravity imaging devices based on gravity sensors

F Integrate quantum sensors with consumer applications including mobile devices

4. Computers

A Operation of a logical qubit protected by error correction or topologically

B New algorithms for quantum computers

C Small quantum processor executing technologically relevant algorithms

D Solving chemistry and materials science problems with special purpose quantum computer > 100 physical qubit

E Integration of quantum circuit and cryogenic classical control hardware

F General purpose quantum computers exceed computational power of classical computers

Quantum Technology

the new European flagship research project

Timeframe

- May 2016: Commissioner Günther H. Oettinger announces the project
- Sept-Oct 2016: High-Level Steering Committee appointed to prepare the project within a 1-year mandate
- flagship project cycles: ramp-up phase from 2018, full project phase from 2020

Goals

- Europe has to become the leading force of the second quantum revolution
- consolidate and expand European scientific leadership and excellence in quantum research, including training the relevant skills
- kick-start a competitive European quantum industry to position Europe as a leader in the future global industrial landscape
- make Europe a dynamic and attractive region for innovative business and investments in quantum technologies, thus accelerating their development and take-up by the market
- establish and support the long-term cooperation of academia, industry and businesses
- make the transformative technologies accessible for the entire society

Quantum Technology

the new European flagship research project

Priorities

- innovative spirit: place Europe at the forefront of the second quantum revolution
- the research agenda needs a common denominator for the entire stakeholder spectrum from the academia through startups and SMEs to multinational corporations
- national programs and commitments have to become part of the agenda, but there has to be an overarching added European value
- inclusiveness should be rooted in excellence, not necessarily the broadest reach
- education, young innovators and innovators need to be a prime focus of the programs, in great part building on Europe‘s world-leading academic background

Added value

- combine the strength and flexibility of a broad, de-centralised programme with the clustering and coordination of focused initiatives
- promote international collaboration, exchange and networking of people and information between different centres, and across academia and industry, thus fostering mobility and knowledge exchange
- integrate and enhance collaboration between education, science, engineering and innovation

High-Level Steering Committee

of the new European QT Flagship Project

Setup

- collectively represent the diversity of stakeholders in Europe: 12 Academic and 12 Industry Members, appointed by the European Commission
- work in an open and transparent way, together with the wider community of stakeholders from academia and industry, in close collaboration with the EC and Member States
- deliver an Intermediate Report by February 2017, and a Final Report by Q3 2017, preparing the framework of the flagship initiative

Mission

- advise the European Commission in the launch of the QT Flagship by delivering

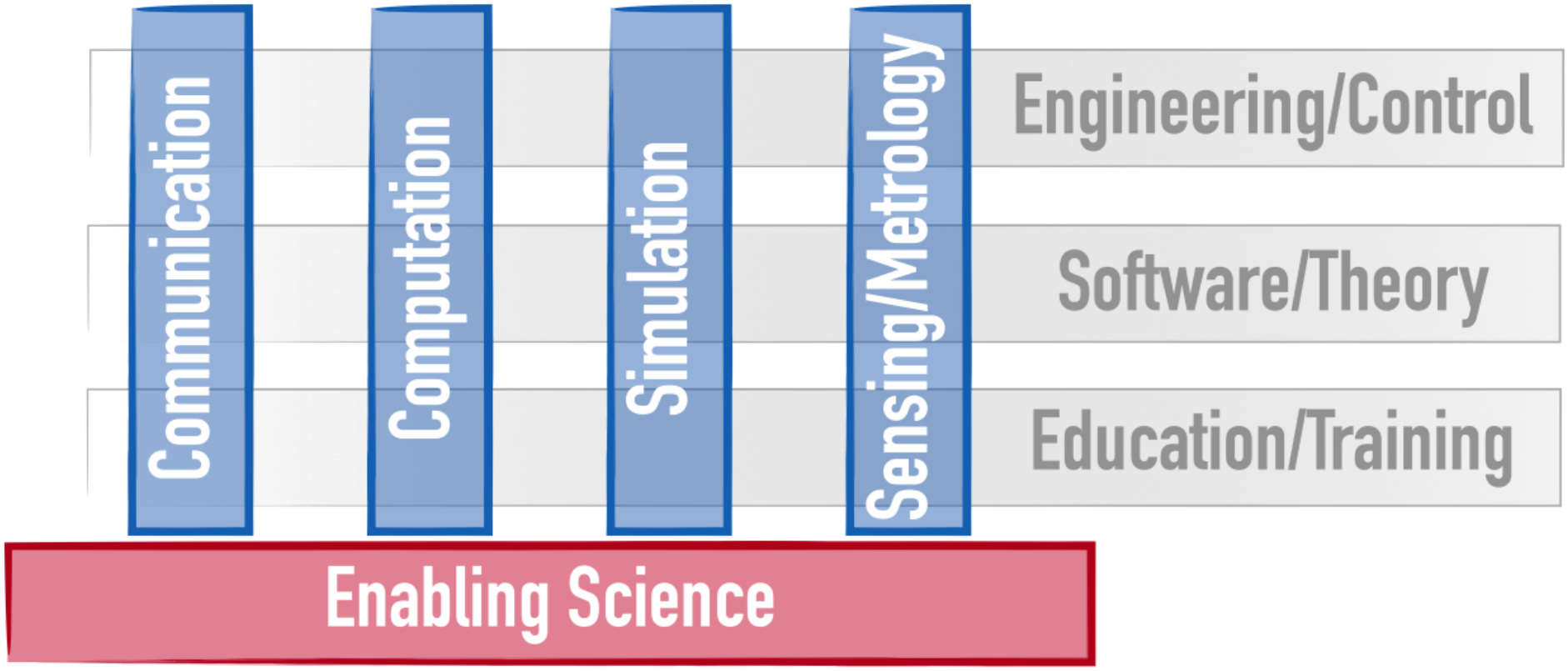
  - a **Strategic Research Agenda**, taking into account industrial aspects. It should include a long-term roadmap for the flagship as well as a more detailed agenda for the H2020 ramp-up phase that should start as of 2018

  - an **Implementation Model**, proposing a concrete implementation approach both for the ramp-up phase within H2020 as well as for the longer term beyond H2020

  - a **Governance Structure**, including the internal governance of the flagship as well as the relations with the EC, the Member States and the relevant funding agencies

Strategic Research Agenda: Structure

of the new European QT Flagship Project

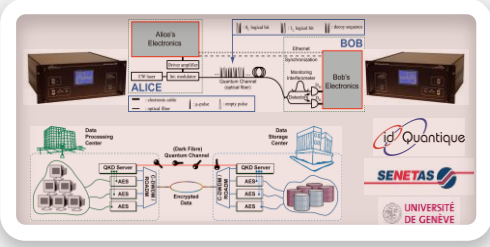


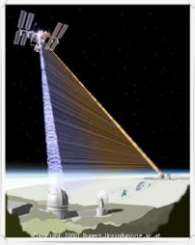
Strategic Research Agenda
of the new European QT Flagship Project

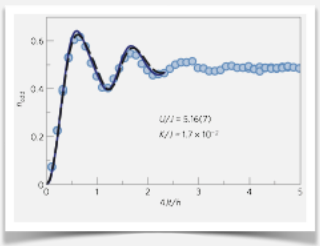
Vertical pillars

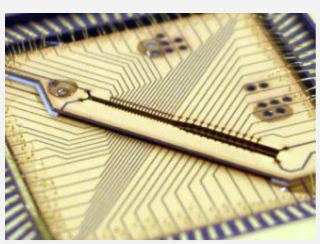
The flagship program should be structured into four pillars, each one addressing a vital application area of a future knowledge-driven industry:

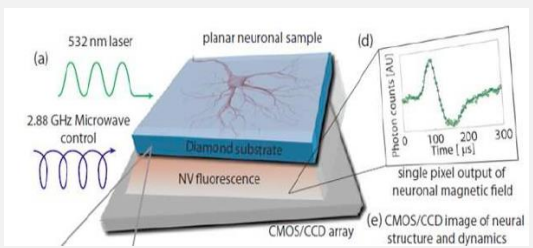
- **Communication**: guarantee secure data transmission and long-term security for the information society by using quantum resources for communication protocols
- **Computation**: solve problems beyond the reach of current or conceivable classical processors by using programmable quantum machines
- **Simulation**: understand and solve important problems, e.g. chemical processes, the development of new materials, as well as fundamental physical theories, by mapping them onto controlled quantum systems in an analogue or digital way
- **Sensing and metrology**: achieve unprecedented sensitivity, accuracy and resolution in measurement and diagnostics, by coherently manipulating quantum objects











Strategic Research Agenda
of the new European QT Flagship Project

Cross-cutting activities

The cross-cutting activities support the pillars' mission-driven objectives, while providing a structure to identify common concepts, capabilities and opportunities to develop more efficient solutions:

- **Enabling Science**: develop novel ideas and concepts that can have a major impact on the four pillars, ranging from theoretical and experimental basic science to proof-of-principle experiments, capable of delivering concepts, tools, materials and processes
- **Engineering and Control**: advance the understanding, design, control, construction and use of new technologies and driving their transition from concepts, theories, one-off and proof-of-principle experiments, by facilitating materials fabrication and miniaturised or integrated solutions for robust, high-yield and scalable devices and systems
- **Software and Theory**: develop quantum algorithms, protocols, and applications, and connect to tools for control and certification and understanding the quantum advantage
- **Education and Training**: set up specific programmes for training a new generation of skilled technicians, engineers, scientists and application developers in QT and foster ecosystems for them to work on shared mission-driven technologies and to develop tools and software

Implementation model
of the new European QT Flagship Project

Values of the program

- realize the highest level of transparency in the development process
- show openness to involving emerging actors, attract the best talent also from other fields
- fair evaluation of proposals with top priority to excellence and impact

Priorities

- pan-European dimension, with goal-oriented academia-industry partnerships
- the largest part of the available funding of the Flagship should be used to fund ambitious and at the same time focused and coherent research and innovation projects, which should be selected through a peer-reviewed call for proposals.
- translate the diversity of project sizes into milestones, follow up on them with appropriate key performance indicators and benchmarks
- consider lessons and implement best practices from the two already running FET Flagships
- register and maintain intellectual property and patent rights
- bring the QT Flagship into public spotlight, keep it there through a stream of successes
- sustainability over a timescale also going beyond the 10-year flagship program

Governance structure

of the new European QT Flagship Project

Principles

- simple and efficient organizational structures, implementing experiences from other flagships
- the governance setup will depend on the the final Strategic Research Agenda priorities
- the structures have to be effective on all levels, from stakeholder representation to the scientific, advisory, supervisory and executive boards, including efficient feedback loops

Priorities

- flexibility and agility is needed to follow changes in the European and global research, market and political agendas
- provide a continuous consultative forum for the QT community
- establish differentiation between the funding agencies and the flagship initiative

Main bodies

- European Commission / Governance Board / Executive Board / Program Management
  QT Community / Board of Stakeholders / Advisory Council

Innovation Mindset

in the QT flagship

the project shouldn‘t only support the next European generation in science, it should prove to be appealing on a global talent level

subsidies for science-based startups, high-risk/high-gain investments and young researchers

aim: turn scientific discoveries into industrial innovation


we need more time…
and more qubits…

Thank you for your attention!

juergen.mlynek@physik.hu-berlin.de
juergen.mlynek@falling-walls.com