Quantum Communication

Better define the 10 year vision, especially for entanglement based networks
- A vision for a universal quantum communications network
- But needs specific targets for entanglement based networks, eg metro-area networks or connecting cities
- Define the applications of a “quantum internet” beyond encryption
- Define scalability, both in terms of distance and number of nodes

Explain need for a quantum communication infrastructure
- will help for defining standards, certification, developing applications
- analogy with building transport infrastructure

Important to attract expertise of other communities (eg engineering, telecom, crypto)
- focus on building prototypes and complete systems
- hybrid (quantum and post-quantum) quantum-safe solutions
- target missing elements in supply chain not made in EU (components, electronics)
- quantum comm infrastructure will help

Explain our advantages more clearly
- explain the threats
- eg long term secrecy of data

Quantum Technologies:

Quantum Computing - Quo vadis?

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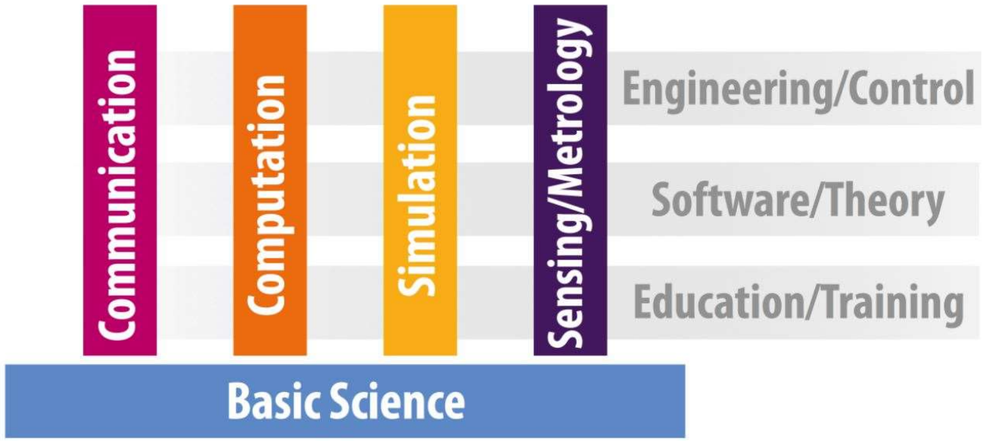
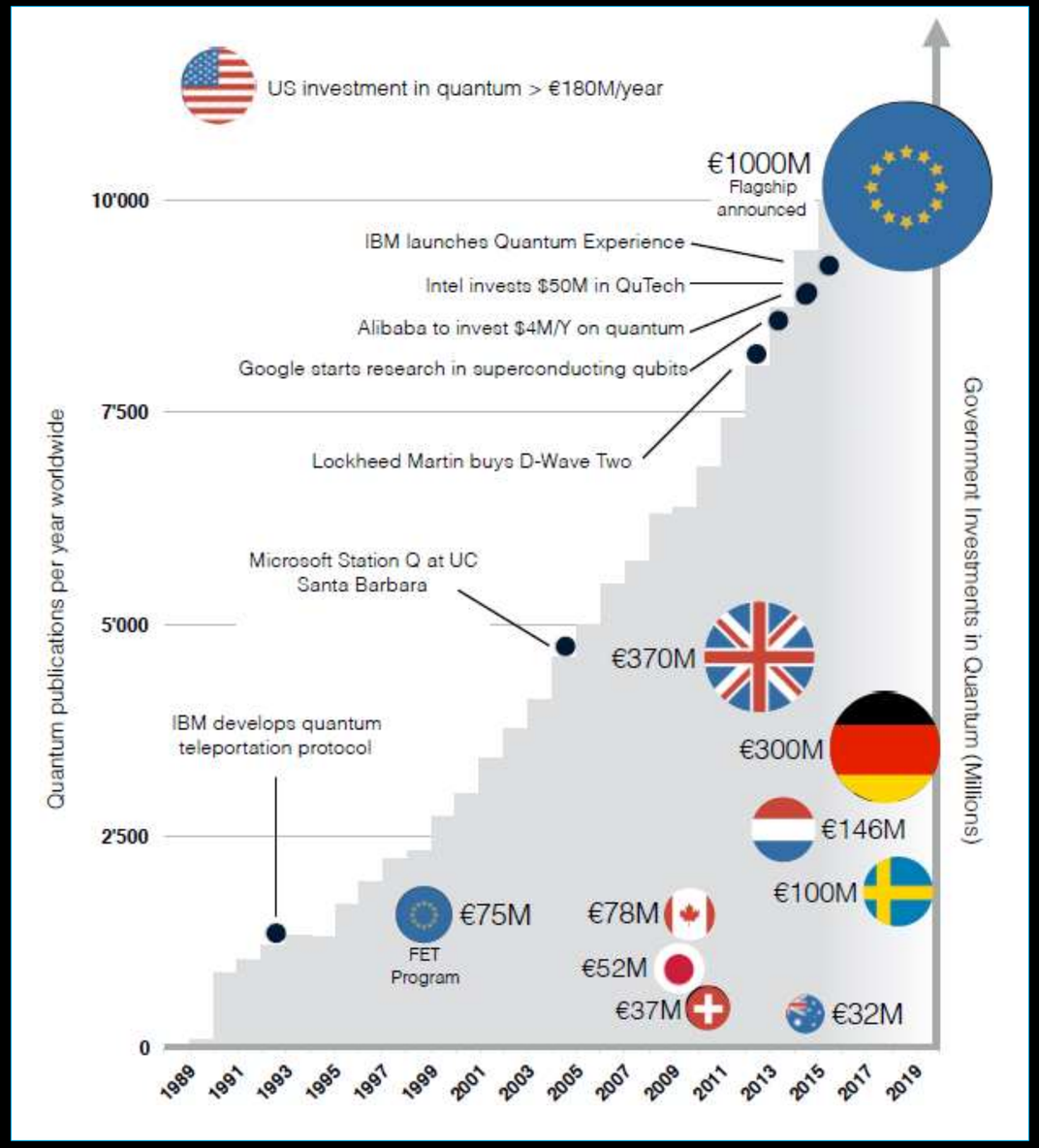


QUANTUM

Massive global investments



- Governmental programs
- Growing interest of industry
- Number of scientific publications
- **And – this is not the end**

China building world's biggest quantum research facility

K. Ensslin et al., "Switzerland: At the quantum crossroads", upddated, http://www.swiss-quantum.ch (2017);

South China Morning Post, Monday, 11 September, 2017.

Global Environment

China – focussed activity / Masterplan

US – focussed activities / Masterplan

Metrics: Quantum Volume!
Quality qubit initialization, readout, of gate operations, connectivity of qubits, connectivity between platforms, number of entangled qubits, qubits and gate architecture, options for scaling, error correction, result certification.

Central Question

How do we play a leading role in this endeavor?

- Networks with focus on **one scientific goal?**
  Which allows for joining different platforms under a common theme, and also for comparing their performance under chosen metrics?

- Networks with technology aims, **including science and industry partners?**

Optimization of future Flagship calls required

System-point of view to be taken into account

Scale up along realistic roadmap

New ideas „boiling“ out from side projects – new concepts

➢ How to attract **key European industry** players?

Noise level of competing technologies is still too high – industry is waiting for sufficient stabilty

User consulting and training is required to make observing industry aware of feasable applications and fit to enter collaboration

No major EU hardware IT company – lack of IT semicond. Manifacturing

Not happy with the hype – fashion of Qcomp.

Software startups for US & Chinese hardware ?

- Big, localized centers **AND/OR** distributed networks of excellence?
  Pros and Cons!

Consensus, distributed excellence and link to different industries preferred

Big centers, once mature techology level has been achieved. Strategic investiments to provide competitiveness in future

Big localized centers have failed in history in many cases

Better building the structures on existing distributed European excellence

➢ How to build a self-sustaining industrial – academic eco-system?

University (Expertise)

Industry Major player I (experienced)

Industry Major player II (newcomer)

Startup

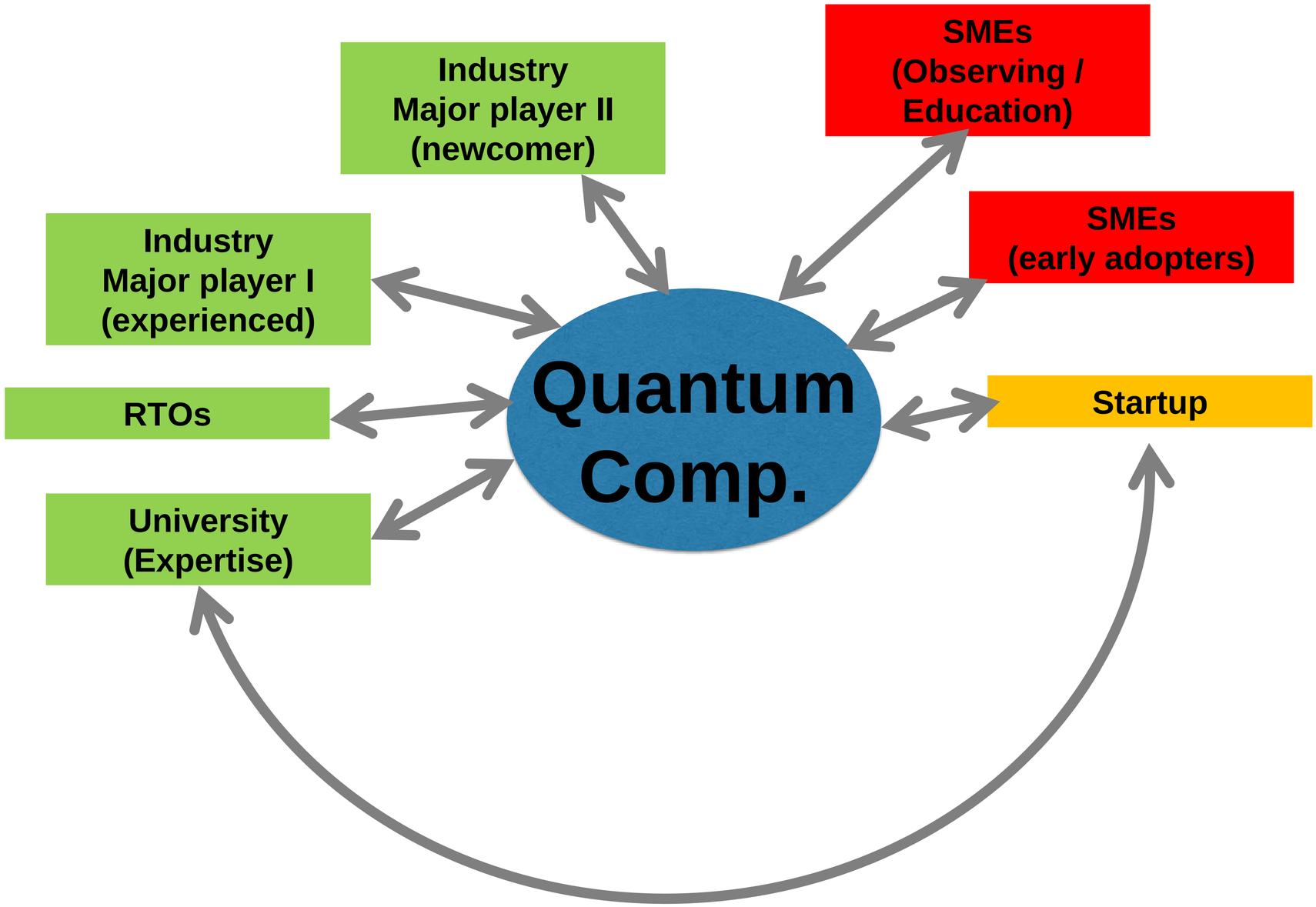
SMEs (Observing / Education)

SMEs (Key competence)

Gouverment research lab.

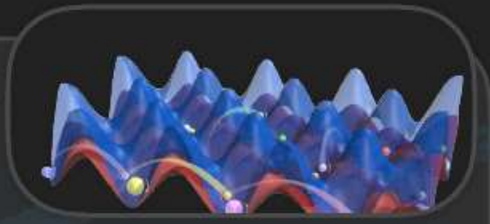
Clinets and early adopters

Suggestions for FP9



QUANTUM SIMULATION: SPECIAL PURPOSE - PROBLEM DRIVEN

Analog QS



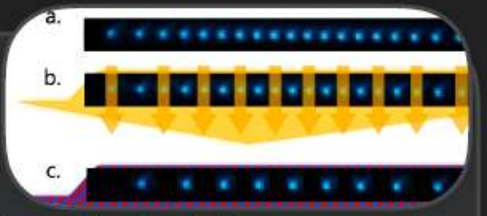
0-5y:

- Strongly correlated simulations
- Improved control/temperatures

6-10y:

- High energy problems

Digital QS



0-5y:

- Digital interactive/hybrid methods w.-o. quantum error correction
- Quantum advantage

6-10y:

- Small scale QEC

Quantum heuristics

0-5y:

- Coherent quantum annealers
- Industry-motivated applications (routing, portfolio opt., path finding)

6-10y:

- Quantum-enhanced machine learning

Building upon road map document on QSIM (Bloch, Eisert, Lewenstein, Kuhr)

QUANTUM

Sensing & Metrology

- Extended discussion on top-down vs. bottom-up approach
- Roadmap needs to combine application requirements, business cases and scientific/technological challenges
- Missions considered very relevant. What is the process to propose/define/select mission?
- Series of workshops and online platform required to improve connectivity between science and applications

Basic Science

At present stage QTs still demand Basic Science efforts which will be more efficient at the EU level.
For example:

Rubstness of quantum processing
Exotic materials
Interface between classical/quantum information
Effective theories for quantum many-body states
New cooling techniques
Fundamental limits of quantum sensing
Ultimate control in chemical reactions
Quantum tests of gravity

New tools:

Cross disciplinary Training/networking/exchange for young/senior physicist and engineers

Engineering & Control

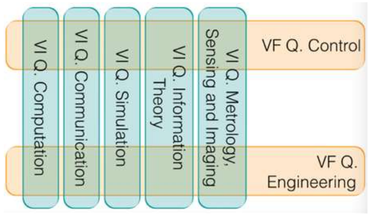
- ca. 25 pax, mixed thy/exp, acad/ind/RTO
- Quantum optimal control theory and practice presentation
- How to quantify what is best / most efficient? Right figure of merit?
- Quantum Engineering challenge presentation: Tasks and challenges
- Connection science/industry? Component/Device/systems view?

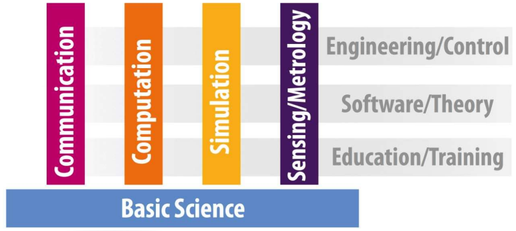
Engineering & Control

- Engineering of tools vs. engineering of final products
- Openness of hardware vs. IPR? Trust/verification in components needed (… all the way to certification)
- Role of moonshots as motivator / End-user perspective is important
- Role and realism of common engineering and control challenges
- how to find connections (industry-academia-rto) ? workshop?
- pull cross-cutting themes out of the initial research projects
- Need of standardization and well-defined interfaces for engineered parts (HW+SW) for these goals

Software & Theory

- The role of theory has changed.
- Industries are getting more interested on quantum software.
- How do we give visibility to the industry oriented theoretical work?
  It should not go to basic science.





Time for a pillar on quantum software?

Quantum algorithms
Machine learning
Verification
Classical simulation of quantum devices
Post-quantum cryptography

Points to be considered:

1. There will be a quantum software industry.
2. Easier for Europe to play a leading role
3. Easier for start-ups.
4. Clearer picture for stakeholders: industry and academia
5. Risk for an almost empty pillar?

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