QC WARE

Q2B

2017

QUANTUM TECHNOLOGY

THE NEW EUROPEAN FLAGSHIP INITIATIVE

Prof. Dr Jürgen Mlynek
Chairman of the High-Level Steering Committee

Mountain View, California, December 5, 2017

Europäische Kommission

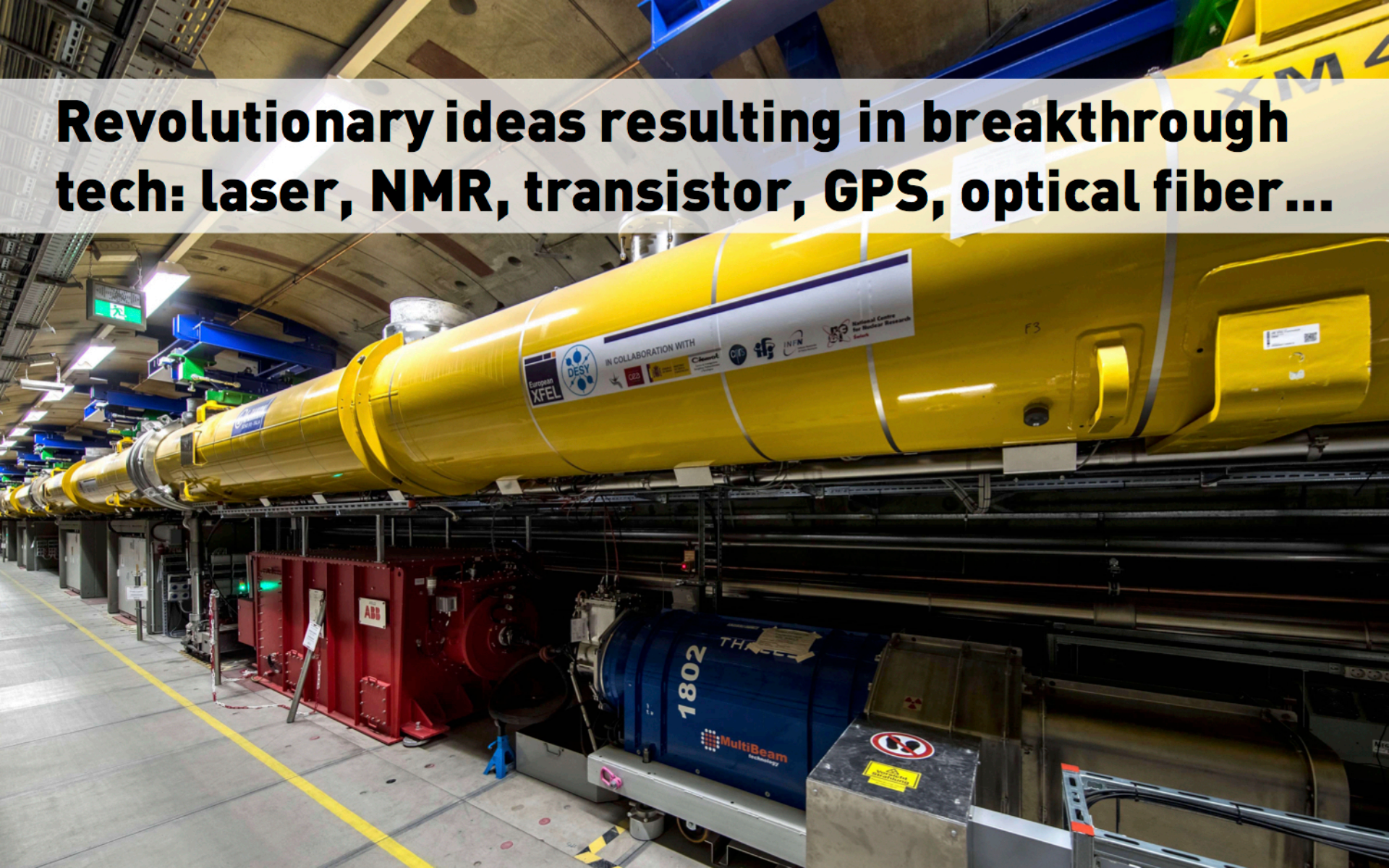
HUMBOLDT-UNIVERSITÄT ZU BERLIN

Europe paving the way for the first quantum revolution...

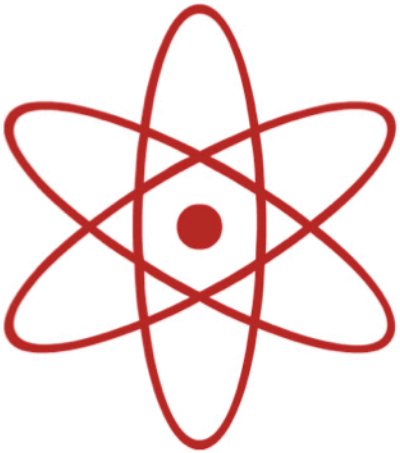
„Does the moon also exist when no one is looking at it?“

Albert Einstein

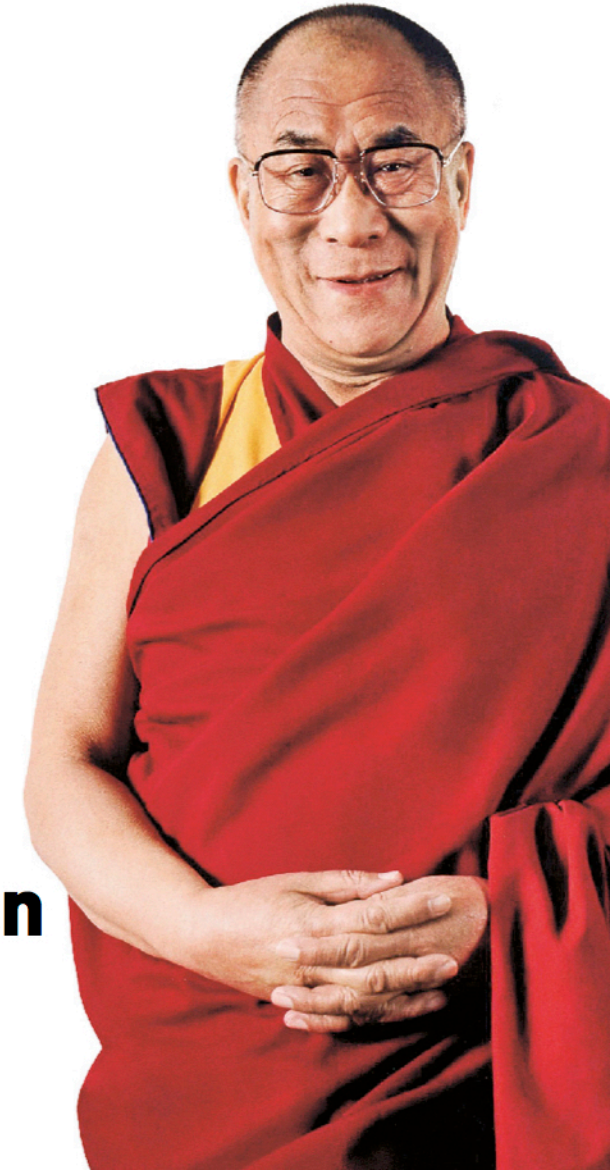
Revolutionary ideas resulting in breakthrough tech: laser, NMR, transistor, GPS, optical fiber...



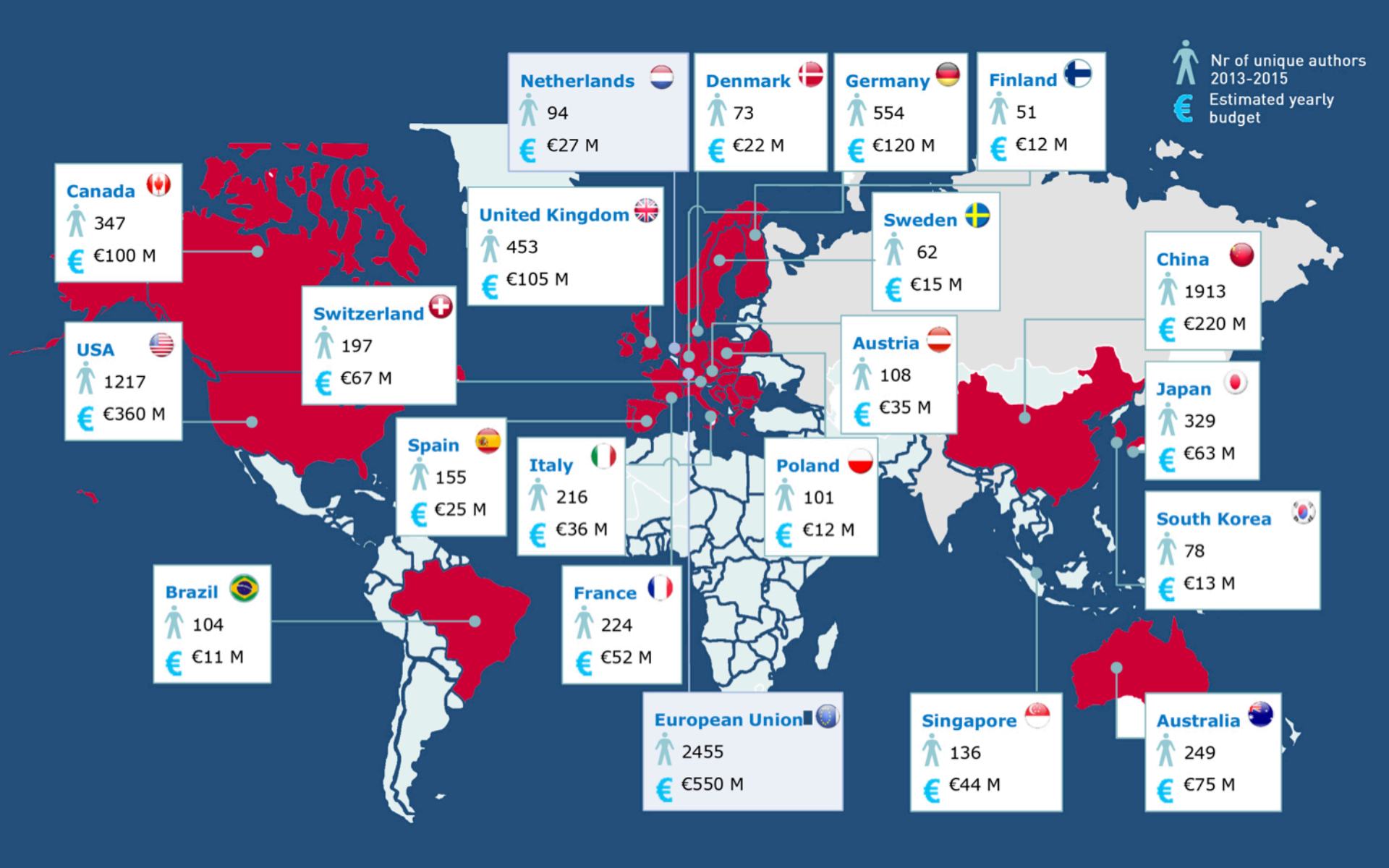
The second quantum revolution: superposition & entanglement



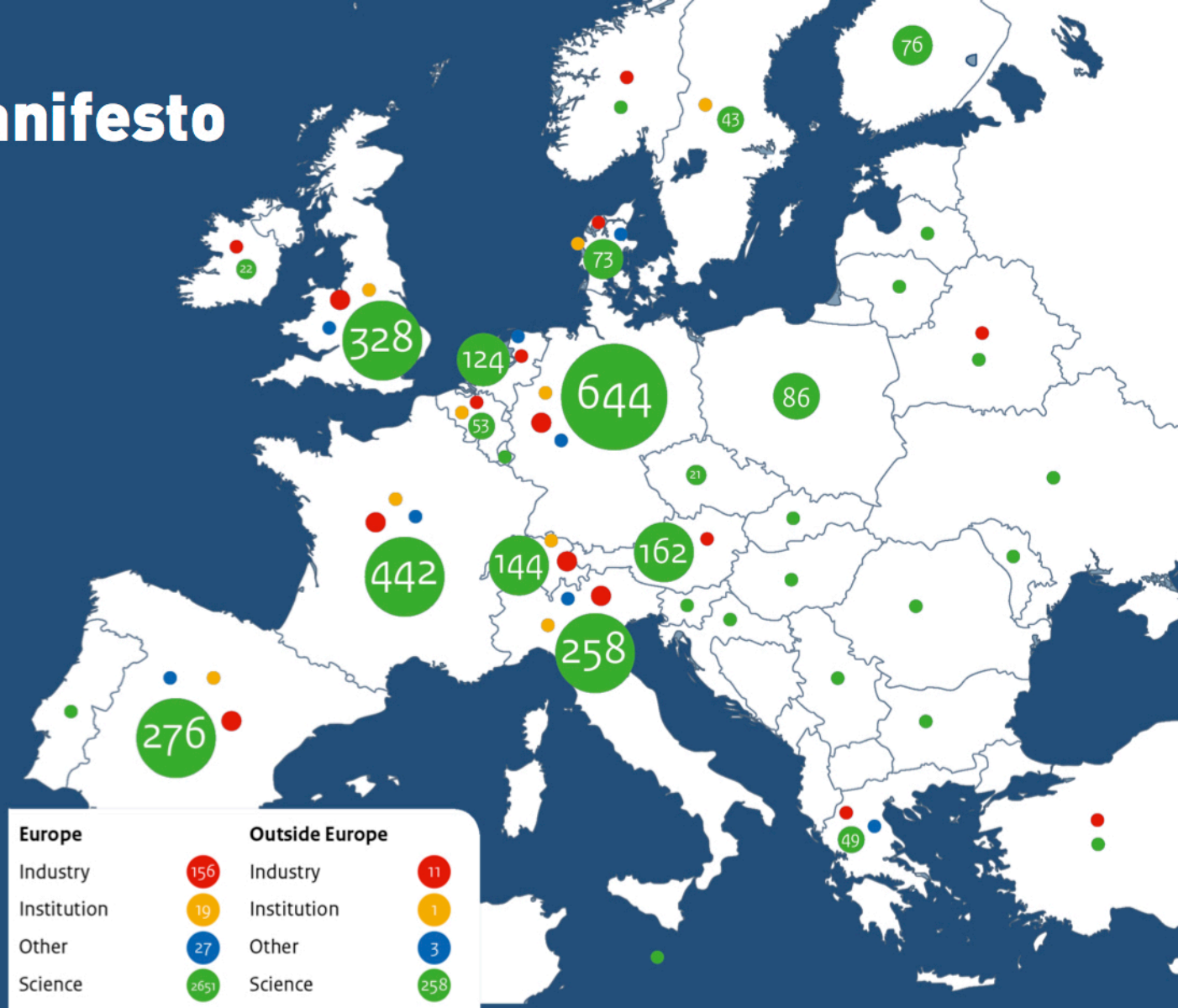
Creation, detection & manipulation of single quantum entities



THE QUANTUM TECHNOLOGY FLAGSHIP INITIATIVE


Nr of unique authors 2013-2015
Estimated yearly budget
Netherlands 94 €27 M
Denmark 73 €22 M
Germany 554 €120 M
Finland 51 €12 M
Canada 347 €100 M
United Kingdom 453 €105 M
Sweden 62 €15 M
China 1913 €220 M
Switzerland 197 €67 M
USA 1217 €360 M
Austria 108 €35 M
Japan 329 €63 M
Spain 155 €25 M
Italy 216 €36 M
Poland 101 €12 M
South Korea 78 €13 M
Brazil 104 €11 M
France 224 €52 M
European Union 2455 €550 M
Singapore 136 €44 M
Australia 249 €75 M

Quantum Manifesto 2016



High-Level Steering Committee

of the QT Flagship Project

Prof. Dr. Jürgen Mlynek, Chairman, Humboldt University Berlin
Prof. Dr. Rainer Blatt, University of Innsbruck
Prof. Dr. Vladimir Bužek, Slovak Academy of Sciences Bratislava
Prof. Dr. Tommaso Calarco, University of Ulm
Prof. Dr. Per Delsing, Chalmers University Gothenburg
Prof. Dr. Elisabeth Giacobino, CNRS Lab Kastler-Brossel Paris
Prof. Dr. Marek Kuś, Polish Academy of Sciences Warsaw
Prof. Dr. Eugene Simon Polzik, Niels Bohr Institute Copenhagen
Dr. Maria Luisa Rastello, INRIM Torino
Prof. Dr. ir. Wim Van Saarloos, KNAW Amsterdam
Prof. Dr. Lluis Torner, Institute of Photonic Sciences Barcelona
Prof. Dr. Ian Walmsley, University of Oxford

Dr. Cyril Allouche, Atos SE
Jaya Baloo, KPN
Dr. Paolo Bianco, Airbus D&S UK
Dr. Michael Bolle, Bosch GmbH
Dr. Fabio Cavaliere, Ericsson
Dr. Guido Chiaretti, ST Micro
Dr. Daniel Dolfi, Thales
Dr. Norbert Lütke-Entrup, Siemens AG
Dr. Graeme Malcolm, M2 Lasers
Dr. Iñigo A. Martinez, VLC Photonics
Dr. Markus Matthes, ASML
Dr. Grégoire Ribordy, ID Quantique

Observer: Prof. Dr. Maria Chiara Carrozza, Sant'Anna School Pisa

Mandate of the HLSC

- work in an open and transparent way, together with the wider community of stakeholders from academia and industry, in close collaboration with the European Commission and EU Member States

- deliver an Intermediate Report by February 2017, and a Final Report by September 2017, preparing the framework of the initiative

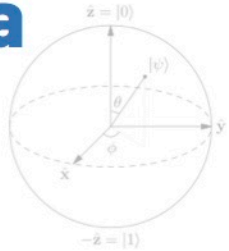
- advise the European Commission on:

  - **STRATEGIC RESEARCH AGENDA**
  - **IMPLEMENTATION MODEL**
  - **GOVERNANCE STRUCTURE**

STRATEGIC RESEARCH AGENDA

Final Report of the High-Level Steering Committee

Structure of the Strategic Research Agenda



Communication

Computation

Simulation

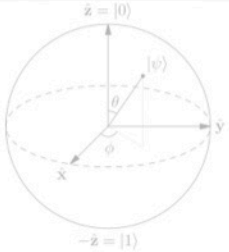
Sensing/Metrology

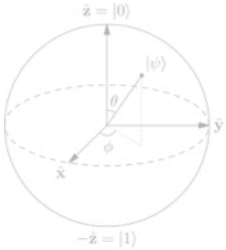
Engineering/Control

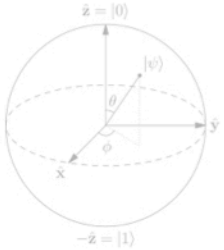
Software/Theory

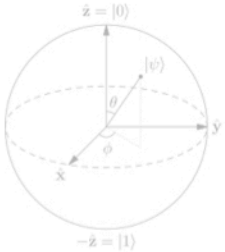
Education/Training

Basic Science

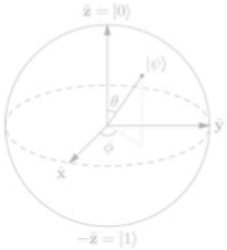


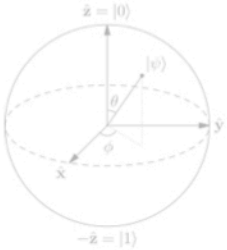


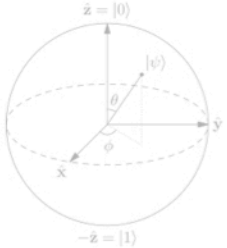




QUANTUM COMPUTATION







3

6

10

In 3 years fault tolerant routes for >50 qubit quantum processors are available

In 6 years quantum processors fitted with quantum error correction or robust qubits outperform physical qubits

In 10 years quantum algorithms demonstrate quantum speed-up and outperform classical computers

3 6 10

In 3 years...

- algorithms with quantum advantage or fault tolerance with >10 qubits will be created
- a path will be mapped to >50 qubits
- advanced demonstrators will show the full technology chain, quantum software with few-qubit applications and advanced tools will validate and verify quantum computation and processors
- primitives for distributed quantum computing to form larger clusters will be tested

In 6 years infrastructure for hundreds of qubits and operating quantum computer prototypes will be available and logical qubits will outperform physical qubits

In 10 years fault-tolerant algorithms will be developed in a scalable architecture, reaching hundreds of qubits with the perspective for user-friendly quantum computers to be operated by staff at data centres

Software/Theory

- verification and validation
- more efficient error correcting codes and architectures
- fault tolerance
- discovery of new algorithms
- compilers
- resource optimisation
- evaluation of non-circuit based computational models
- connection to quantum simulation

Engineering/Control

- optimal control schemes
- suitable hardware
- materials
- cryogenics
- lasers
- electronics
- microwave sources
- detectors
- low-level software

Large-scale projects

- development of quantum software, compiling, algorithms, control and efficient error correcting codes
- demonstrate quantum advantage or fault tolerance via leading quantum computing platforms with more than 10 qubits, as well as the potential to scale systems to a useful size

Small, focused projects

- show basic single-qubit operations and coherent qubit-qubit coupling
- demonstrate more attractive scaling potential with spins in solid state (e.g. electrons in quantum dots, defects and impurities), clusters and molecules, linear optics, neutral atoms or topological quantum states

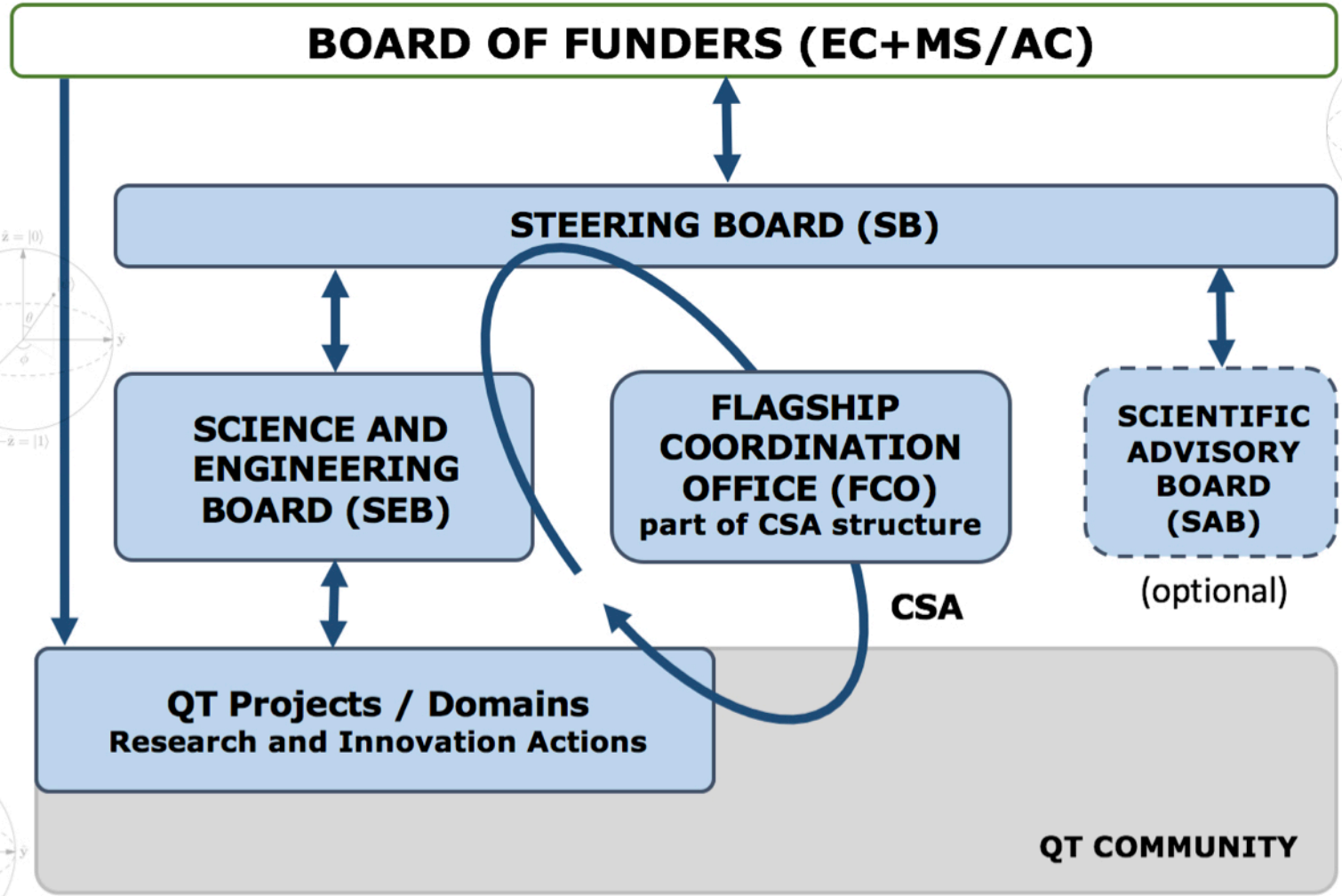
IMPLEMENTATION MODEL

Final Report of the High-Level Steering Committee

HOW?	TRANSPARENCY, OPENNESS, EXCELLENCE AND IMPACT, SUSTAINABILITY, ALIGNMENT
WHAT?	SOCIAL IMPACT, COMMERICAL EXPLOITATION, DEMANDING GOALS, PROJECT MILESTONES, HIGH-RISK/HIGH REWARD R&D
WHO?	ACADEMIC AND INDUSTRIAL PARTNERS FROM ALL OVER EUROPE
WHEN?	NATIONAL SUPPORT AS EARLY AS POSSIBLE Q1 2019: START OF THE FIRST FLAGSHIP PROJECTS IN THE RAMP-UP PHASE

GOVERNANCE STRUCTURE

Final Report of the High-Level Steering Committee


BOARD OF FUNDERS (EC+MS/AC)
STEERING BOARD (SB)
SCIENCE AND ENGINEERING BOARD (SEB)
FLAGSHIP COORDINATION OFFICE (FCO)
part of CSA structure
SCIENTIFIC ADVISORY BOARD (SAB)
(optional)
CSA
QT Projects / Domains
Research and Innovation Actions
QT COMMUNITY

RAMP-UP PHASE OF THE QT FLAGSHIP INITIATIVE

Overall framework

- timeframe: 2018 – 2020
- total budget: €148m, with up to €10m per project in QC

Challenge

- create a world-leading knowledge-based industry in Europe
- move advanced quantum technologies from the laboratory to industry with concrete prototype applications and marketable products

QC scope

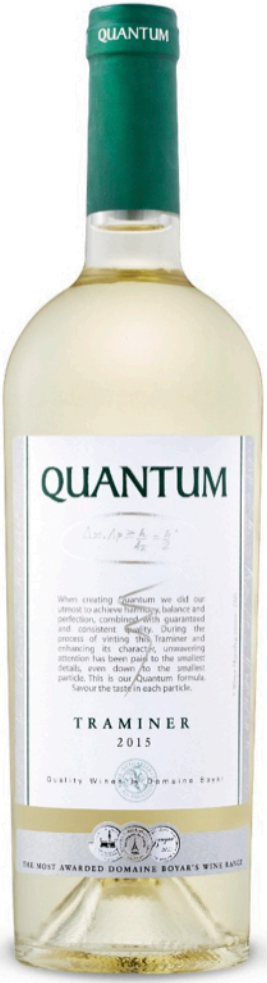
- move the technology up the TRL scale
- development of open quantum computer experimental systems and platforms, integrating the key building blocks such as quantum processors (>10qubits)
- address the scalability towards large systems (>100 qubits)
- demonstrate the quantum advantage

IMPACT OF THE QT FLAGSHIP INITIATIVE

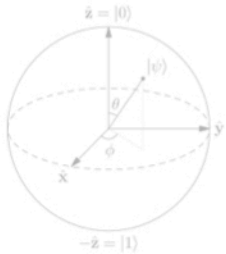
Innovation mindset

Value creation in Europe

AIRBUS DEFENCE & SPACE
Alcatel·Lucent
ASML
Atos
BOSCH
e2v Bringing life to technology
Google
Honeywell
HUAWEI
IBM
IDQ FROM VISION TO TECHNOLOGY
imec
intel
Microsoft
NOKIA
SAFRAN AEROSPACE · DEFENCE · SECURITY
SIEMENS
SINGLE QUANTUM
THALES
TOSHIBA
µQUANS PRECISION QUANTUM SENSORS

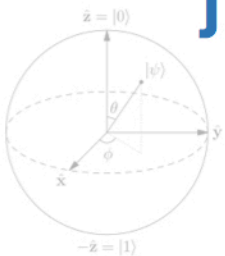


Download the Final Report:



tinyurl.com/qt-hlsc-report

Thank you for your attention!



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